INSURANCE FOR CLIMATE ADAPTATION:
OPPORTUNITIES AND LIMITATIONS

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ABOUT THIS PAPER

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ABOUT THE GLOBAL COMMISSION ON ADAPTATION

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Executive Summary

Climate change jeopardizes socioeconomic stability, and sets back efforts at development. The increasing frequency and severity of climate-change-driven disasters threaten lives and livelihoods, food security, water supply, property security, and economic prosperity across the globe. **Adaptation** is vital to make society resilient to the impacts of climate change.

Adaptation means increasing our ability to recover from specific disasters; reducing vulnerability and promoting resilience (both physical and financial) to catastrophe. **Insurance** can be a key tool in both these aspects of adapting to climate change. First, it provides the flow of capital to support communities and infrastructure to recover from disasters. Without adequate insurance, the burden of paying for losses falls largely on individual citizens, governments or aid organizations, with significant impact upon already straining government budgets, and economic and social hardship for those affected. Countries with high insurance cover recover faster from disasters, and increasingly, governments are recognizing the role and benefits of insurance in transferring risk from disasters. Yet there is a large and even widening 'protection gap' of underinsurance. Second, insurance contributes to the wider understanding of climate-change risks, and helps promote measures that individuals and communities can use to improve their protection from climate-change-driven disasters. For example, insurance expertise in risk evaluation helps to make the economic case for flood defences, or for changes to how and where buildings are constructed.

Using insurance is a step away from crisis towards risk management, and it strengthens socio-economic resilience under a changing climate. However, it is only one of the available disaster-risk financing mechanisms. It thus needs to be considered within a broader fiscal framework that also includes international assistance, catastrophe debt drawdowns, and other financial securities, disaster reserves and budgets. Furthermore, insurance and other disaster risk financing mechanisms are only part of the solution: they need to be integrated into other resilience and adaptation measures as part of a comprehensive **climate adaptation strategy**. In this report, we make recommendations to maximize the benefits of insurance for climate adaptation:

Recommendation 1: Invest in open-source models that provide a long-term view of climate risk and link to insurance solutions.

Recommendation 2: Joined-up policy-making to put climate-risk models at the heart of national adaptation strategies.

Recommendation 3: Develop consistent climate adaptation regulation and standards across countries.

Recommendation 4: Foster insurance innovations that can respond to a changing climate risk landscape.

Recommendation 5: Strengthen dialogue between insurers and policy-makers around Build Back Better.

Recommendation 6: Converge insurance, humanitarian and development agendas.

Recommendation 7: Promote and invest in risk literacy throughout society.

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1. Introduction

Climate change is increasing the frequency and severity of extreme weather events, such as flood, hurricane and drought, and therefore jeopardizing sustainable development. Climate-change-driven disasters accounted for about 91% of the 7,255 major disasters between 1998 and 2017.[1] These disasters pose risks not only pose immediate risk to life, but also damage food security, water supply, human security, and economic growth over the longer term across the globe.[2]

Insurance, when put in place, provides financial resilience: it generates a flow of capital to support societies to recover from disasters. In the absence of adequate insurance, the burden of paying for losses falls largely on citizens, governments or aid organizations, with significant impact upon already straining government budgets, and economic and social hardship for those affected.[3] When disasters strike, insurance can provide financial protection to reduce setbacks to technological, economic and societal development: it is therefore a mechanism for securing a society's developmental gains. However, insurance is only one of the available disaster-risk financing mechanisms. It needs to be considered within a broader fiscal framework that includes other financial securities, disaster reserves and budgets, catastrophe debt drawdowns, and international assistance.

For maximum effectiveness, insurance also needs to be incorporated into a long-term, comprehensive climate adaptation strategy. **Climate adaptation** requires both physical resilience – the minimising of vulnerability to hazard, and the provision of systems for response and recovery – and financial resilience to the risks which remain. Insurance can play a key role in both aspects of adaptation strategies. Insurance can help vulnerable countries to absorb residual financial risks that have not otherwise been mitigated; but through its expertise in risk assessment, it can also identify and incentivize effective physical resilience measures.

However, insurance itself needs to innovate and adapt, to better address the needs and challenges of climate adaptation. Insurance, particularly for property assets, is a relatively short-term product, renewing every 1-5 years, whereas climate adaptation necessitates long-term strategies integrating physical and financial protection. The evolution of insurance products, alongside their integration into wider risk-management frameworks, will best support the identification and reduction of climatic risks, and increase preparedness for, and resilience to climatic disasters.

Our **aims** in this report are 1) to describe and critically evaluate available insurance-based mechanisms, using examples that can be understood by a wide audience; and 2) to explain the key opportunities and challenges in using insurance mechanisms within wide-ranging strategies to increase resilience to climate change.

The report has the following **structure**.

Section 1 is this introduction to the report.

Section 2 outlines the principles of insurance and the risk-transfer value chain through which it operates.

Section 3 explains different types of insurance products and their various applications and beneficiaries.

Section 4 outlines the key reasons for, key mechanisms, and potential challenges of government intervention in insurance provision.

Section 5 briefly indicates how insurance fits within a wider fiscal framework to affect risk prevention, risk reduction, preparedness, and recovery at macro-, meso- and micro-levels.

Section 6 introduces the opportunities of insurance mechanisms for climate adaptation, while Section 7 discusses its key challenges.

Section 8 makes key recommendations about how insurance expertise can better address the growing threat of climate-change-driven disasters.

The *Glossary* defines key terms used in this report.

2. The insurance value chain

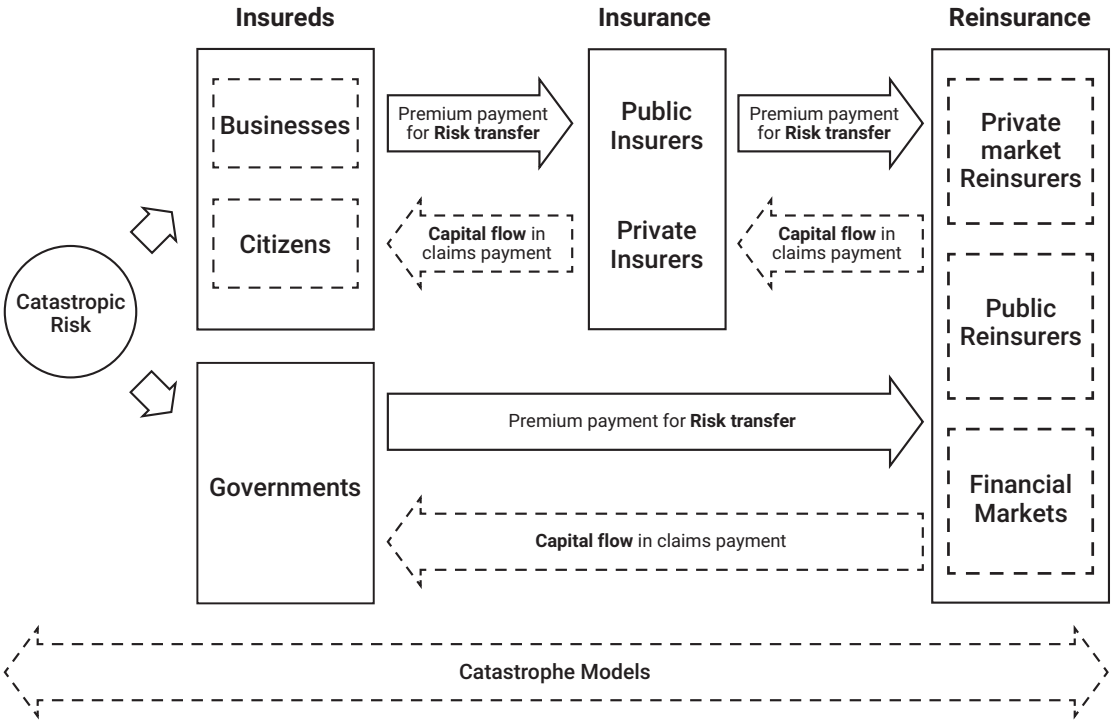
The purpose of insurance is to transfer a specified risk from one party, an insured, to another party in order to increase the insured party's capability to withstand financial loss. The potential for financial loss arising from catastrophic events, such as a major flood or a tropical storm is transferred to insurers. These insurers are capitalized to absorb part or all of the financial impact of these catastrophes, with their capital ultimately financed by the premiums they are paid for issuing insurance policies. In this section we will explain the risk-transfer process and the principles of insurance that underpin this process.

2.1 Risk-transfer process

Climate change exacerbates catastrophic risks that are a potential source of loss for ***citizens and businesses***. For example, with the threat of tropical storm, a flood, or a forest fire, a citizen might be concerned about the risk of damage to their house, while a manufacturer might be concerned not only about the damage to their industrial plant, but also about the subsequent business interruption. Climate change is making more and more citizens and businesses vulnerable to such risks, so that a global macro-roadmap (such as the Paris Agreement) is required for action on adapting to climate change. Individually, citizens and businesses can also protect themselves from some of this potential loss by becoming **insureds**, meaning they transfer some of that risk through the risk-transfer value chain (see Figure 1).

The **insurer** accepts the risk from insureds, charging them a **premium** for this service. Insurers are then responsible for the potential future financial losses according to the terms and conditions of the **insurance policy**. If a loss occurs, insurers will pay **claims** arising from the insurance policy. For example, individual citizens can buy an insurance policy to protect their house from flood. They can decide the level of cover, and how much risk to retain themselves. For instance, if a citizen buys house insurance they can decide for which risks they will be covered (e.g. flood, fire), to what level of their house value they will buy cover, and what 'excess' or threshold they will pay themselves for damage before their insurance starts to pay. These different factors affect the price of their premium. More complete cover for multiple risks; full replacement value of the house; lower (or no) excess will each cost more, because

FIGURE 1 The insurance value chain: Trading in catastrophic risk



more of the risk is transferred to the insurer. Based on such decisions, insured citizens pay an annual premium for their policy which is much lower than the actual cost of their house being rebuilt if a disaster strikes. Then if a flood damages their house, insurers will be liable for the covered loss and will issue payouts. Insurers calculate premiums, so that over time, the accumulated premiums from many insureds cover the probable losses of the unfortunate few. Insurers are typically private sector companies operating for a profit, but may in some political contexts be publicly-owned or government legislated not-for-profit insurers developed to fill a particular social need, as we explain in section 4.

Reinsurers - Insurers make profit from trading risk through insurance policies. These policies, collectively, form their insurance portfolio. However, insurers must also protect themselves from having to pay too many claims simultaneously after a catastrophic event, such as a series of hurricanes in the Gulf of Mexico that could strip their capital reserves. They therefore transfer risk to reinsurers in order to protect their capital reserves and ensure they will remain solvent to pay claims after a disaster. Essentially reinsurance is insurance for insurance companies. Each insurer creates a reinsurance program that transfers some of their risk to a panel of multiple reinsurers, each of whom covers a percentage of future potential losses. As in insurance risk transfer, reinsurers agree the conditions upon which to pay their share of that insurer's claims, in return for which they receive a reinsurance premium. The capital which reinsurers need in order to pay claims comes from different actors: (1) private market reinsurers that accept insurance risk for a profit; (2) other capital market providers such as hedge funds, mutual funds, sovereign wealth funds, pension funds, and institutional investors, also accepting risk for a profit; and (3) public sector or government-legislated reinsurers operating as not-for-profits to address a specific protection gap (see Section 4).

Apart from citizens and businesses, ***governments*** also transfer risk. Governments' balance sheets and their publicly-owned assets are also exposed to natural catastrophes. For example, a government might be concerned about the risk of tropical storm damage to infrastructure such as roads, electricity grids and hospitals. The government's balance-sheet would be badly affected by having to use its own capital for reconstruction, if no insurance is in place. Governments typically have significant catastrophe risk exposure compared to individual citizens or businesses. Lower-income countries especially – but not excepting wealthy countries with large government balance sheets – may therefore choose to transfer risk directly to the reinsurance industry (see Section 4.3): to both private market reinsurers and the wider capital markets.

Catastrophe **models** are used across the value chain for risk assessment and analysis, in order to facilitate risk transfer. Models allow insurers and reinsurers, corporations, governments and other public agencies to evaluate and manage their exposure to catastrophic risk, including pricing any risk they will transfer. Catastrophe models consist of three parts:

1) ***Hazard*** is about the probabilities of occurrence and severity of any particular potential disaster, such as a tropical storm or flood, at a given location, within a specified time period.
2) ***Exposure*** refers to the inventory of elements to be insured, such as property values by location; taking note of specific characteristics such as building materials, typical uses, age, and replacement cost.
3) ***Vulnerability*** assesses the level of damage which would be expected at different levels of intensity of a hazard. For example, when a storm surge hits an area with weak building regulations and few flood mitigation measures, it is more vulnerable to loss compared to an area that has strong flood control infrastructure and strong building regulations. Vulnerability assessment may include secondary impacts such as business interruption.

Risk = Hazard × Exposure × Vulnerability

A model can run tens of thousands of scenarios, based on these three components, to identify what might happen under various plausible catastrophic events. Models aim to calculate the possible losses for any particular portfolio of insureds' properties in any specified location. Based on these calculations, it is possible for (re)insurance companies to make **financial** decisions about the appropriate premium prices they should charge to ensure an acceptable level of return for the risk being transferred. These premiums provide the basis for both profit and for the capital reserves that (re)insurers would need to pay claims for the risks they have taken – their capital solvency, which they must demonstrate to regulators. Models may also be used by insureds, to evaluate the cover they obtain relative to the premium paid.

Importantly, models are regularly recalibrated based on recent events. Modelling is therefore at the front line in the evaluation of climate-related risks, because any likelihood that severity may increase, or that occurrence may be more frequent, will lead to increased losses, and hence require higher premiums. In particular, society's need to understand **climate change** impacts can be at least partially met by using such models to 'run' different possible future climate scenarios. In this way society can explore risk, and estimate the financial (and human) value of adaptation. For (re)insurance companies this exploration of future scenarios will reveal both commercial opportunities, and challenges to the design and uptake of insurance products (see Section 6.1 and 7.1).

The expertise required to develop models is usually expensive. Models may be proprietary, with licenses issued by developers to industry parties for a fee. Or they may be owned in-house by industry parties as part of their own intellectual capital. Recently, development organizations have supported the generation and sharing of open-source models for evaluating risk and making decisions on risk transfer.[4]

Brokers are an important reservoir of expertise in risk. Their key role is as market intermediaries, facilitating risk transfer from insureds to insurers (or from insurers to reinsurers). They do not themselves provide the capital or hold the risk, but they are often involved in a wide range of industry activities, from analysis to pricing, from claims to capital provision. As a result, their knowledge base connects diverse risks, models, insurance actors, government and inter-governmental bodies, and insurance products from around the world; and they promote transparency and competition within risk trading. All this expertise may improve joined-up thinking on climate change adaptation.

2.2 The three principles: Risk pooling, risk pricing and risk diversification

The risk-transfer value chain works to accumulate premiums across all insureds, so that the few affected insureds can receive a payout to support their recovery. Three principles ensure that, in the event of disaster, each party within the value chain has sufficient capital reserves to pay the leveraged claims upon them.

Risk pooling means that many insureds are needed to help spread the insurers' financial risks of payouts from expensive claims more evenly. In particular, insurers hold a pool of risk, from across a large enough population, that their combined premiums can provide sufficient capital reserves for insurers to cover the risk of large payments to a few of them in any given year. Pooling is not simply about economies of scale, but is based on a long history of cross-subsidization. Insurance can be provided to all in the pool, even though statistically, some insureds face higher risk. For example, people with houses next to a river face higher risk of flood. Nonetheless, with a large enough pool of insureds, the overall effect of the likelier or greater losses to these insureds is distributed across the pool.

Risk pricing: Despite the cross-subsidization effects of risk pooling noted above, there has always been an effort to ensure that those at higher risk also pay more for their insurance. Growing improvements in modelling (see Section 2.1) have made it possible to identify more accurately specific properties or insureds most likely to trigger a claims payment, and to charge higher premiums for them. This is known as *risk-reflexive pricing* and is now a key component of offering insurance policies.[5]

Risk diversification is a technique used by (re)insurers to spread loss exposures. A (re)insurer needs a wide range of risks spread across a wide geographical area, diverse enough to minimize correlation between those risks. A diversified portfolio may include different types of potential hazards, such as flood, earthquake and fire; for different assets from homes, to crops, to commercial businesses; and all of these may be located in different regions with different exposure to any of these hazards. For example, a (re) insurer may diversify across earthquake in California, and hurricane in Florida, and this may be further diversified with flood in Europe and wildfire in Australia to minimize the possibility of having to pay multiple claims simultaneously. (Re)insurers with highly-diversified portfolios can achieve better capital optimization than those that are highly concentrated on a specific risk in a specific location – that is, the same amount of capital in reserve is capable of underwriting more risk if the risk is diverse. Diversification enables (re)insurers to demonstrate better solvency to regulators without having to transfer more risk away, which would come at a cost to their profitability that would be passed on to consumers through higher premiums.[6]

These three principles are critical to understand how insurance products can further climate adaptation. Insurance

products are a powerful form of leveraged capital for responding to disaster. But they can only work within a robust business model, in which for insurance to be available and effective it needs to conform to sound insurance principles of risk pooling, risk-reflexive pricing, and risk diversification.

3. Insurance products

Insurance is one financial instrument, comprising a range of products which operate in different ways. This section explains different types of insurance products and their usefulness in different contexts.

The following four considerations affect the choice of insurance product(s):

1. The position of the risk across a spectrum from low-frequency-but-high-severity events, such as a one-hundred-year flood that can devastate a society, to events of high-frequency but low-severity, such as low-impact floods during rainy seasons.
2. Any strategies in place to cover different stages of post-disaster risk management, from early action, to disaster relief, to recovery support, and reconstruction.
3. The speed of financial relief needed for each of these post-disaster stages, from immediate response to later reconstruction.
4. The parts of society and the economy that the product is intended to support, ranging from particularly-vulnerable citizens, to individuals and small businesses, to the commercial sector, to government assets and infrastructure.[7]

Individual products may support different aspects of these four considerations.[8]

3.1 Micro-, meso- & macro- levels of insurance

Insurance products can operate at micro-, meso- and macro- levels, which we now briefly explain.

Micro-insurance is the direct insurance of individual or small-business policyholders. Increasingly, however, micro-insurance has come to mean the development of micro-products to insure the most vulnerable individuals in low-income countries; a parallel with the concept of micro-finance. Micro-insurance has grown over the last decades in developing countries.[9] An example is R4, a partnership between the World Food Programme and Oxfam, which aims to increase the resilience of the livelihoods of people most vulnerable to weather-related risks. This program provides subsidized micro-insurance products which are linked to the specific risks faced by these individuals, the poorest farmers, enabling them to access crop insurance R4 takes an innovative approach to risk management by integrating risk-transfer (through insurance) with risk reduction. Farmers and their families in some of the lowest income countries are mobilized to take risk reduction action such as the rehabilitation of low-lying lands for rain-fed rice cultivation, the construction of dikes and stone barriers, the construction of dams and the creation of vegetable gardens, in return for insurance cover.[10] Yet micro-insurance continues to have a relatively modest global reach relative to its potential[11] indicating problems in both the development of suitably tailored products and distribution channels, and, particularly issues of affordability for the most vulnerable.

Meso-insurance refers to those situations in which the insured is not an individual, but rather an aggregation of individuals under a collective body. For example, the insured might be an organization that supports a collective of farmers within an area. This meso-level organization buys an insurance product designed to cover the collective of individuals; the individuals themselves are indirect beneficiaries of financial protection. They will receive payments from the meso-level organization, based on any claims paid to the organization through insurance. Such products are often taken out on behalf of vulnerable individuals who do not have adequate protection – or indeed, any protection – through direct personal insurance, as per the example of the Kenya livestock insurance program in Section 3.3.1.

In *macro-insurance*, the policyholder is typically a public entity, such as a government, which pays an insurance premium to provide payouts in the event of national disaster, such as a flood or tropical storm. The payout on the government product can be used for multiple purposes on behalf of the population of that country. For example, the payments might be used to maintain government services, in order that they can continue to support disaster relief. They might also be linked to supporting the most vulnerable individuals, for example through disaster contingency plans that channel specific measures for relief, such as provision of food, to those beneficiaries most likely to be affected by the disaster (see Example 1 in Section 3.3.2).

3.2 Indemnity products

Most of our understanding of insurance products is based on the principles of indemnification for loss against an actual physical asset. Assets such as a house, factory, commercial building, or power plant may be owned by a private individual or company, while other assets such as roads, hospitals or educational facilities can be publicly owned. The key to indemnified insurance products is that the asset has a known value for reconstruction; it is made of particular types of materials, in a specific location. This means the asset in question can be allocated an insured value, against it which can be indemnified. The price of the insurance product will be based on the cost of repairing the property and the likelihood of partial or full loss. High-value assets in very exposed areas, such as expensive infrastructure or high-value commercial buildings in coastal areas prone to both wind and storm surge, will be charged a higher premium than assets of lower physical value, not in an area at high risk of an extreme weather event. The insurance contract is based on indemnification of the specific assets, and hence, actual losses to those assets are the trigger for payment.

Actual loss trigger: In order for payment to be released on these products, an independent loss adjustor is appointed to inspect the damage after the event. The loss adjustor will usually be an expert in the specific type of damage or loss and its valuation, working for an independent company that therefore has no conflicts of interest with either the insured or the insurance company. They assess the damage and the cost to repair or reconstruct, after which a claim is paid by the insurance company to the owner of the asset. This claim may potentially be for the total of the insured value in the case of a full loss, according to the terms of the insurance contract. The trigger for payment is thus tied to the actual loss experienced by the asset owner, in respect of the identified event for which they were insured.

The key features of indemnification insurance products in terms of the four considerations above are:

1) Indemnity products are common for low-severity, high-frequency events, such as household, small business and commercial cover against a range of potential losses that may not affect society but are still critical to the financial stability of those policyholders. If risk is reinsured, indemnity products can also provide for low-frequency, high-severity, catastrophic events.
2) Indemnity products are particularly suited to the expensive reconstruction phase of post-disaster management.
3) Due to the process of loss adjustment that accompanies claims, indemnity products are not suited to immediate disaster response. They are much more appropriate to the medium-and longer-term responses of rebuilding physical assets.
4) Insurance policies will pay out against insured value, which may not include any additional premium payments to build to a higher standard after loss. Hence, payments for reconstruction will not necessarily lead to the rebuilding of more resilient assets. Nonetheless, where insurance is linked to government regulations about rebuilding and enhanced construction codes it may be possible to increase the future resilience of the assets in question (see Example 3, Section 6.2). Such linkage indicates some of the opportunities for insurance in climate adaptation (see Section 6.4). However, rebuilding and construction codes arise from government legislation, and are not typically something over which the insurance company has control or jurisdiction (see Example 4, page 25 and Section 7.2). One of our recommendations is therefore a stronger dialogue between insurance companies and legislators (see Section 8) about how insurance can financially support improved standards for reconstruction, in order to better future proof assets for climate adaptation.

3.3 Parametric or index-based products

3.3.1 PRINCIPLES OF PARAMETRIC PRODUCTS

Sometimes an insurance product is not tied to an actual loss. *Parametric* types of products may be used for situations in which the insured is not looking for payment for reconstruction of a specified asset, but rather for funds to respond to a catastrophic event. A parametric or index-based insurance product is a product in which a payout is triggered by a specific set of parameters or indices of the type and severity of the disaster. The parameters are pre-agreed, and form the basis of the insurance contract. The buyer of the product can use the payment as they please – from emergency relief to reconstruction – but the payment is not necessarily tied to identified damage or loss. These

products, which were initially developed as catastrophe bonds to supplement reinsurance capital for the insurance industry, have become particularly important for responding to catastrophic events in low-income countries where insurance penetration is low. Indeed, they have been at the forefront of much industry innovation in providing disaster response for these countries. Such products comprise the following components:

Trigger: The insurance cover can be triggered when pre-defined event parameters are met or exceeded, measured by an objective model-based index of catastrophic events. For example, the event can be a tropical cyclone, where the parameters are the wind speed at particular pre-determined locations: or a flood, as measured by a rainfall volume and frequency over defined periods in a particular geographic location. Weather-related events are very common parametric triggers.

There are many other possible index triggers such as market indices, crop yield, power outage and more. For example, an area yield trigger is typical for agricultural products. For this trigger, an index is calculated based on the typical aggregate yield of a crop across an area, and its historic experience of yield losses during a specified peril, such as drought. On the basis of this index, the product will trigger according to the average loss experienced by the crop across the area, rather than being calculated on a farm-by-farm basis. These products can work at the meso-level of insurance to provide aggregate cover. Examples include government-legislated or government-backed agricultural insurance pools supporting a collective of farmers within a certain area.

Index triggers can also operate at the micro-level to support vulnerable individuals in low-income economies, by triggering particular types of payout that help to allay disaster for these individuals. For example, in Kenya an index-based livestock insurance product was developed, with a trigger for payout when pasture levels begin to decrease because of drought. The trigger is based on a satellite measures of the color of the ground as a proxy for dryness that will affect the amount of livestock feed available. The aim of the trigger is that the payout should be made while the pasture is decreasing, in order to provide livestock owners with money to purchase feed for their animals.[12] This scheme suffered from insufficient demand during its initial pilot phase,[13] until the Kenyan government subsidized farmers' premiums to encourage participation in the scheme. Since then, the scheme has been sufficiently successful in providing payouts to 275 nomadic cattle farmers, that it is now being scaled up.[14]

Payout: a pre-agreed payout is issued if the parametric or index trigger is reached or exceeded, regardless of the actual physical loss sustained. If the wind speed or rainfall volume occurs within the pre-specified location, or the area yield, or industry loss is reached, as determined by an objective third party and specified in the contract, this triggers the payment.

While indemnified insurance payouts are calculated based on the losses incurred in relation to the insured value of a specified asset, there is no single way of calculating the payout on an index-linked product. Rather, the payouts are calculated according to the specific contractual basis of the product, which can be tailored to the specific demands for protection, making it a more flexible product than indemnity products. For example, payment can be triggered by modelled losses (that is, the losses *projected* to occur for the particular severity of disaster experienced, as opposed to *actual* claims for losses), when they exceed specified thresholds. By contrast, as we note in Section 3.3.2 below, payouts on disaster liquidity products may be calculated to meet the modelled, projected costs of early action for the recovery phase after disaster. In yet other examples, such as the Kenyan livestock product, payment may be calculated based on a lump sum to provide feed for a specified number of animals per farmer in an affected region. Such payments typically have progressive triggers, enabling partial payments where lower levels of the presenting conditions are met. The payout could therefore be equal to or less, but not more than the agreed amount in the contract. Critically, the common feature of such products is that payments can be issued much sooner, when the pre-agreed, modelled parameters or indices are met, rather than by the actual loss assessed after the disaster.

3.3.2 DISASTER LIQUIDITY PRODUCTS

Parametric insurance has been a critical innovation in developing rapid payout to support relief in the immediate aftermath of a disaster. As explained above, triggers can enable a payout if, for example, a hurricane occurs at a specified wind speed in a set of agreed geographical locations, as declared by an independent third party. Because there is no need for the loss adjustment associated with

indemnity products, once the parameters are met, the country can receive an almost immediate payment. This rapid injection of capital can then be used for immediate disaster relief, such as providing food, clean water, or shelter.

These products are therefore often termed disaster liquidity products. As disaster response is typically a government responsibility, these products usually operate at a macro-level. For many sovereigns in low-income economies that struggle to meet disaster response costs through their own balance-sheets, these products have transformed their ability for rapid humanitarian relief. While reconstruction may come from international aid or other international development budgets, for these countries, immediate disaster relief is a priority that can be a viable and affordable product for them to purchase, even though they may have had little history of insurance.

The timeliness and flexibility of parametric insurance products have thus encouraged their innovative application to many hazards to which low-income countries are vulnerable. For example, payments triggered by drought can be used to support food security and protect the assets of the most vulnerable, as evidenced by the African Risk Capacity (ARC) (see Example 1).

EXAMPLE 1

Mauritania is impacted by drought on a frequent basis. It was among the first countries to purchase an insurance policy from ARC for an estimated premium of $1,394,000 for a total cover of $9,000,000 for the agricultural season from July through November 2014. The product worked. After a very poor rainy season, Mauritania received a payout of approximately $6,326,000 in January 2015. With this rapid payment which gave them liquidity in the face of impending disaster, Mauritania had the necessary resources to alleviate a humanitarian crisis, providing 50,000 households with 50 kilograms of rice and 4 liters of oil each over 4 months (April – July 2015). The timeliness of the payout had a positive impact; it prevented migration, and protected livelihoods and assets, by avoiding the distressed sale of livestock.[15]

These schemes are not without challenges. Such products are still under development, and can fall prey to errors and insufficient information in the parameters or indices that are being modelled. For example, in Malawi under a similar situation to Example 1, ARC's payments were delayed because of modelled assumptions about the type of grain being used. These assumed greater resilience to drought than was actually experienced by Malawian farmers, who were using a different grain. Such different outcomes from the same scheme show the importance of continuously improving the models involved in developing products.

It is also important to assist those taking out products to examine what exactly they wish to protect, such as food security in the event of a climate-related disaster, as opposed to necessarily a climate-based rainfall index per se.[16]

3.3.3 SUMMARY: PROS AND CONS OF PARAMETRIC AND INDEX-BASED PRODUCTS

Parametric and index-triggered products have valuable roles in addressing the four considerations of our opening paragraph, but they also raise some potential concerns.

These products can be valuable for the following reasons:

- They can address catastrophic risk, since the triggers and payouts can be linked to low-frequency, high-severity events such as tropical storm, excess rainfall, drought and other non-climate related events like earthquakes.
- They can be used to support the most vulnerable: either as micro-insurance, albeit such `` are largely in their infancy; or, primarily, as meso-insurance, where they are designed as an aggregate product that can provide collective support for vulnerable individuals. For such individuals the development and purchase of a specific individual product would be neither viable for the insurer, nor affordable for insureds.
- They are timelier, issuing payouts quickly and decisively to reduce the immediate human and economic impact of the disaster. Since such products are often tied to modelled triggers rather than actual losses, loss adjustors do not need to assess the value of damage to assets which can be a lengthy process, particularly in the aftermath of a major disaster. Rather, the payment can be made within a matter of days to weeks, which

enables immediate action in response to climate-related events.

- They have higher design and purpose flexibility than indemnity-based products, as they can be tailored to specific issues or scenarios from which an insured, such as a government or a farmers' cooperative, desires protection. For example, payments can be linked to the provision of food security in the event of a climate-related disaster, rather than the reconstruction of assets.

Due to the above four features, these products are a leading component of innovative risk-financing strategies for disasters as diverse as weather-related events, agricultural risks, and pandemics. However, these products also present challenges:

- Basis risk may occur, in which there is a difference between the payout triggered and the gravity of the disaster experienced by the insured. This may be both negative basis risk, in which the event severity is greater than that reflected in the modelled triggers, or positive basis risk, in which a payment is triggered despite the events being less severe than anticipated for that trigger.[12] At least some of such risk will be counteracted as models improve, particularly where there is funding to absorb the lessons from losses and use these to update models and indices. However, because these products rely on models rather than actual loss, there will always be incomplete information, unknown unknowns, and no model can ever eliminate all error.

- Insureds may lack the financial literacy to select a product that provides protection from the actual disaster that they perceive as threatening (see section 7.4). For example, food security is a specific threat, which may come from multiple different sources, only some of which will be triggered by a particular climate-related product. As products become more refined, and tailored to specific requirements, we can learn from them how to better specify the particular threat.

- From the perspective of climate adaptation, parametric insurance products may provide little incentive to reduce risk, because they are not tied to actual loss. In themselves, these products do not encourage, for example, changing the natural or built environment to make it more resilient to disaster (see Section 7.2 on risk mitigation). Nonetheless, as we noted in Section 3.2 on indemnity, neither is there an automatic link from reconstruction-based payouts to improved resilience. The challenge with all insurance products is to improve their interaction with resilience measures in an integrated climate adaptation strategy. In this case, better understanding of insurance triggers should reveal opportunities to finance improved community resilience schemes, including change to the natural and built environment. Improved resilience will make it less likely that a product will be triggered, making future premiums more affordable, perhaps with less subsidy (see Section 7.1).

4. Government intervention in insurance provision

While insurance is typically a private market mechanism, it operates within the legislative and regulatory framework of government. As underinsurance undermines the socioeconomic stability of society,[17] inadequate access to insurance, or failure in private market mechanisms can trigger government intervention in insurance provision. This section considers such interventions, which can range from governments taking some risk upon their own balance sheet, to using developmental budget funds to subsidize some form of insurance provision for other countries, to introducing schemes such as publicly-funded or publicly-managed (re)insurance pools that enable wider participation in the private insurance market.

These interventions increase access to insurance but can also distort the market, and potentially override the price signals that might incentivize adaptation. Hence, as climate change increases both the frequency and severity of disaster and also those areas that are vulnerable to disaster, such interventions will be needed to be carefully designed to support insurance provision, whilst providing incentives for adaptation. We now briefly consider the reasons for different forms of government intervention in insurance provision, and their benefits and potential limitations.

4.1 Addressing insurance supply failure

Extreme disasters can result in sudden large-scale disruption, or even failure, of the supply of (re)insurance for a specific risk. Disruption of supply occurs because of unexpected large losses that jeopardize (re)insurers' capital reserves and, in consequence, ability to pay claims. They therefore withdraw from providing cover to citizens and companies. Detrimental socio-economic effects follow: for instance, homeowners unable to get residential property insurance may then be unable to get a mortgage; businesses without insurance may struggle to get finance.

In such cases, governments may intervene to maintain the insurance provision that is critical for the socioeconomic stability of citizens and businesses. Typically, governments intervene to develop either:

- a public sector scheme, with the capital reserves necessary to offer insurance products underpinned by a state guarantee, as in the case of the Australian Reinsurance Pool Corporation (ARPC); or
- a private sector but state-legislated scheme, such as the California Earthquake Authority (CEA), in which insurers can offer policies for the particular risks, but these policies will be covered by the state-legislated body.[5]

The schemes mentioned above, ARPC and CEA, aimed to ensure vital insurance provision temporarily to enable businesses to continue to trade, and homeowners to protect their properties.

Governments will usually intervene to restore an existing insurance market where supply has been disrupted, in order to restore socioeconomic stability, but such decisions are neither clear cut nor universal across countries and markets. They are instead based on a range of financial, market and political considerations. It is very rare for governments to provide this backstop where there has not been an insurance market to be disrupted, although there are some examples of governments intervening to create a new market for very severe risks of a non-climate nature, such as the Turkish Catastrophe Insurance Pool (TCIP) for earthquake.

However, if disruption in supply is long-term rather than temporary, this is usually a signal that a particular risk is becoming too volatile – meaning too likely to result in extremely high and unexpected losses – for the private market to cover above a specific threshold. These signals of increased volatility are to be expected, and heeded, under climate change scenarios which predict more extreme flooding or stronger tropical storm within an area (see Section 6.1).[18] Hence, while government intervention to ensure continuity of supply is valuable to policyholders, long-term disruption may indicate that particular risks need new approaches to ensure adaptation to climate change (see Section 6.2).

The extreme response to insurance supply failure is to remove trade in that risk fully from the market. Government intervention may remove only some of the most extreme risk: a 'top layer' of risk that is too volatile for the insurance industry to provide at a price that is acceptable to consumers. In this case, risk below a certain threshold remains

covered by the private sector in the usual way. For example, one scenario might be that the risk of flooding increases due to climate change. As certain areas and policyholders become higher-risk, the insurance industry may remove risk from its own portfolios by simply not offering flood policies in such areas. A government might then intervene to provide a backstop for flooding that exceeds certain levels of loss; or it might step in to provide flood insurance itself, as occurred with the origins of the National Flood Insurance Program (NFIP) in the USA.

Furthermore, while government intervention ensures insurance continuity, it is important that such schemes do not simply remove the most volatile risk from the market, enabling trading in 'the 'easier' or more profitable levels of risk, as this can distract public and private attention from the critical need for adaptation.

4.2 Mitigating unaffordable insurance

The combination of more frequent extreme weather events, high levels of urbanization in hazard-exposed areas, and increasingly sophisticated risk models able to pinpoint high-risk areas and even specific properties,[19] has resulted in a growing number of insureds in mature insurance markets falling into the "high-risk" category. As insurers need to adhere to risk-reflexive pricing (see Section 2.2), insurance products may 'price out' potential policyholders at high risk. Climate change can exacerbate the protection gap, as more areas and policyholders are added to that high-risk group that is priced out of affordable insurance. This problem has important social implications. In the aftermath of disasters, social inequality is widened between those who were covered, and those who were not. Under-insured parts of society in high-risk areas may never be able to recover financially, unless recovery is met from the public purse.

Risk pooling to address (high) risk-reflexive pricing effects. Governments may endeavor to solve this problem by establishing schemes that make insurance products affordable to those in high-risk areas. In order to reduce the variation in risk-reflexive pricing, governments can artificially stimulate the risk pooling principle of insurance (see Section 2.2). Specifically, they can legislate to spread the true cost of the highest-risk cover across the wider pool of insureds. This may involve a range of interventions such as mandatory insurance – as occurs with the Earthquake Commission (EQC) in New Zealand, where all citizens with an insurance policy must take out earthquake insurance with the EQC – or a cross-subsidization of premiums, with all policyholders subsidizing the 'at-risk' policyholders – as with Flood Re in the UK, where all homeowners with an insurance policy pay a small levy that is then used to reduce the costs of flood insurance to those at most risk.

While mandatory insurance, or cross-subsidy maximize insurance provision across wider society, including the high-risk areas and properties, badly-designed government interventions can also disincentivize climate adaptation. Those at the highest risk of repeated loss are not incentivized to reduce their risk, or change risky behaviors (for example, through structural changes to their property to mitigate the effects of risk), since insurance provision is secured.

This is known as moral hazard, in which policyholders can engage in risky behavior knowing that other policyholders, or the government, will incur the cost. For example, after repeated events in flood prone areas, leading to the rebuilding of highly exposed properties on more than one occasion, the National Flood Insurance Program (NFIP) in the USA has come under attack for precisely this issue, with the criticism that "it is subsidized floodplain development".[20] When the actual risk of living on a floodplain is not reflected in the premium, then policyholders have little incentive to engage in risk mitigation strategies that would lower the cost of rebuilding. Thus, whilst such schemes may be considered to be 'fair' in the sense that they help those not served by private insurance markets to access insurance, by suppressing important pricing signals they can reduce the incentive for investments in adaptation, leading to higher overall economic costs of disasters in the medium term.

Hence, the design of such government schemes and policy-making should consider moral hazard issues that can lead to unintended consequences. Government interventions for insurance provision should also align with actions for disaster resilience and climate change adaptation, if they are to have a strong, lasting impact (see Section 6).

Government interventions towards affordable insurance may also invoke the third principle of insurance, and increase risk diversification. For example, both Spain and France operate insurance mechanisms which, being compulsory, generate a wider pool of insureds; but they also ensure diversification across multiple risks. In practice, they cover homeowner policies of all the risks across the whole

country. Compared to private insurers that are selective, this ensures they can smooth or subsidize risk-reflexive pricing in the highest exposed and so most expensive and potentially unaffordable areas.

While the Spanish and French examples, and other similar government interventions provide comprehensive cover for their citizens, and enable governments to control the pricing of that cover, they can also weaken the private sector's insurance provision. Insurance companies can end up relying on the government-led schemes to take the majority of risks. They then lose – or never develop – expertise in transferring that risk, and therefore lose appetite for such risks. This effect may be counteracted through risk sharing between the government scheme and the private sector. Private-sector insurers can be required to retain some of the risk, and purchase reinsurance for some of it from the government, while the government scheme also purchases some reinsurance in the private sector. This ensures that both the insurance and reinsurance markets hold some of the risk alongside the government, as has been designed into the Australian and UK terrorism insurance schemes, and the UK flood insurance scheme.

All of the above macro-insurance schemes involve some form of either government subsidisation, or government intervention to enable cross-subsidization of risk across the population. While these subsidies may be necessary to protect the most vulnerable (as, for example, with the R4 program noted in Section 3.1), it is important to ensure that the cost of subsidies is transparent and published publicly. In this way the true price of insurance (before subsidy) can be estimated, and the price signal can feed into informed public policy about adaptation investments. By contrast, opaque subsidization may lead to the problems of moral hazard, and diversion of attention from adaptation measures as described above. Subsidization is of course only one of the possible approaches to make insurance more affordable for the most vulnerable and marginalized. Another approach is to design insurance products, such as those of R4, that support their participation. For instance, as women and men often control different crops and livestock or even have different financial capabilities and vulnerability related to the same risks, making insurance products more gender-sensitive in their design has been shown in pilot studies to alleviate some of those issues.[10]

4.3 Protecting the financial viability of sovereigns or sub-sovereigns

While the insurance schemes described above are designed to protect private citizens and businesses, governments may also intervene to protect their own financial viability. Typically, governments own public sector assets, such as critical infrastructure, hospitals and schools. After disaster, they need to pay for losses and reconstruction of those assets, unless they have financial protection in place. In addition, some governments have state and federal emergency budgets for risk management and disaster response that they may also wish to protect to avoid fiscal shortfalls after disasters, and the consequent increases in debt levels. However, some do not have any financial protection, or any disaster management system or emergency fund in place to enable recovery from disasters, and instead rely entirely on international development and humanitarian aid. Increasingly, those development and aid agencies are themselves purchasing insurance to protect their own budgets in years when the demands from disasters are beyond the scope of the budget.

We now explain four schemes which protect the financial viability of sovereigns.

Reconstruction product. First, governments may buy a reconstruction product for their publicly-owned assets, particularly for critical infrastructure such as energy grids, hospitals, schools, and water supply systems. FONDEN in Mexico is a state fund for protection against national disaster. Part of the fund goes into buying cover in the global reinsurance market: the government pays the premiums in order to protect the disaster budget from particularly high demands, and to provide additional funds after a major disaster, to enable the budget to stretch further. When losses rise above a threshold specified in the reinsurance contract, the government can expect a payment to help with the costs of reconstruction. The cover FONDEN buys is based on modelling of the risk of loss to federally-owned infrastructure and assets, and the cost of reconstruction.[21]

This is not only a product for lower- or middle-income countries; it can also appeal to some high-income countries. For example, FEMA in the USA has recently begun to buy a reinsurance product to cover some of the payments arising from their National Flood Insurance Program (NFIP). Similarly, the state of Victoria in Australia indemni-

fies all state-owned assets through the Victorian Managed Insurance Authority (VMIA). The VMIA then buys a reinsurance product in the global market, using risk transfer to further protect state capital reserves for reconstruction. Such schemes, when they are effective, can remove some of the financial burden of recovery and reconstruction post-disaster from government budgets to reinsurance markets.

Disaster liquidity product. Second, as noted in Section 3.3, sovereigns may buy a disaster liquidity product, in order to cover their immediate post-disaster capital requirements, rather than the cost of reconstruction. Sovereigns in developing countries that have high exposure to natural catastrophe often begin experimentation with insurance purchase through disaster liquidity products. The insured is the state, not private citizens or businesses; and the state can often use the payout for any post-disaster requirements, such as petrol for generators, payment of the civil service, or the relocation of citizens. These schemes can be highly effective in providing governments with timely post-disaster liquidity to respond quickly and decisively to reduce the human and economic cost of the disaster.[22]

Publicly-owned insurers. Third, some countries have set up publicly-owned insurance entities to implement catastrophe insurance schemes. For example, the governments of France, Japan, New Zealand, Spain, Switzerland (German-speaking cantons). Turkey, the state of California, and the Republic of China (Taiwan), have all set up institutions that offer property catastrophe insurance to homeowners and businesses, and the governments of Canada, Cyprus, Greece, India, the Islamic Republic of Iran, and the Philippines have all established government-owned insurers to provide agricultural insurance.[23,24] These schemes typically offer insurance subsidized by government. In some countries, these schemes are perceived to have struck a reasonable balance, encouraging individuals to take some responsibility through paying part of the cost of insurance themselves, and thereby restricting the contingent liability of the government. Although it is often successful, if these schemes are not run on an actuarially sound basis they may end up having to be bailed out by the government after a disaster. Hence, the sound fiscal design of the scheme, particularly with regard to pricing risk and ensuring solvency of the government scheme, is critical.

Publicly-owned multi-sovereign schemes. Fourth, some countries, being too small and highly exposed to weather-related disasters to buy affordable products on their own, form multi-sovereign risk pools to purchase insurance-based products together. For example, small island economies are often prone to major devastation from a single peril, such as tropical cyclone. These low-income countries are too small, too undiversified, and their budgets are too limited, to buy a product in the private market at an affordable premium. However, by collaborating, such countries can use risk pooling and risk diversification, two of the principles of insurance, to generate combined power to buy cost-effective insurance products.

Innovative multi-sovereign pools have been developed to support the insurability of such countries. Specifically, governments, inter-governmental organizations such as the World Bank, and donor organizations have supported vulnerable countries to develop risk pools that cover an entire region. These multi-sovereign pools can also reduce transaction costs to countries from contracting with international reinsurance markets, and can promote peer learning – whilst an individual country may only be hit by a large disaster every ten years, they may see insurance working for a neighboring country and so increase their own awareness of the financial and practical value of (re) insurance. Examples include the Caribbean Catastrophe Risk Insurance Facility (CCRIF) which was a pioneer of this multi-sovereign approach, and which has made successful disaster liquidity payments on a range of perils over the 10+ years since its inception, most notably paying more than $61m during the 2017 year of hurricanes that affected the Caribbean. Other such multi-sovereign mechanisms include Africa Risk Capacity, and the Pacific Catastrophe Risk Insurance Company (PCRIC).

4.4 Failures in government intervention

Proactive government interventions in private insurance markets can provide solutions to address insurance supply failures, subsidize the pricing of unaffordable insurance, and provide continuity of insurance to their citizens and society. However, reactive government intervention in disaster response is also prone to government failures that can exacerbate the gaps in protection, as we now explain.

4.4.1 COMMITMENT PROBLEMS

The aftermath of climate disaster is full of high-stakes political leadership and debate, media attention, public

appeals, and well-intentioned actions. Yet well-intentioned responses by governments and the international community often fall short of their aims. The fundamental problem is commitment,[25] whereby after a disaster, farmers and homeowners, subnational governments, and national governments are required to plead for help to benefactors and the international community, all of whom have retained discretion over how to allocate their budgets right up until those pleas for help. This ad hoc post-disaster funding model does not work well. It is too slow; it leads to a fragmented and underfunded response; and it encourages underinvestment in risk reduction and preparedness, thereby increasing the socioeconomic costs of catastrophes. These shortcomings are further exacerbated as disasters become more frequent and severe due to climate change.

The commitment issue can be identified as three separate problems:[26]

1. Disaster relief may be prone to a moral hazard problem, and the classic `Samaritan's dilemma' in particular.[27] Those at risk may deliberately under-protect themselves knowing that governments or donors will come to their rescue. This tendency is, of course, exacerbated where countries either lack the resources or the know-how to protect themselves adequately through insurance mechanisms (see Section 7.4 for recommendations on how to increase risk literacy).
2. Governments and the international community do not undertake the necessary steps before a disaster to avoid disaster-relief misallocation. Many people who should receive aid do not, and sometimes funds are diverted to those who suffered no losses at all. This problem stems from the fact that in the procedure of aid allocation it is difficult to monitor where exactly losses occurred, and to what extent. Accordingly, there is general mistrust towards claims for payouts made by recipients or the agency responsible for disaster relief. The mistrust in the probability of claims being valid results in the benefactor effectively giving less aid (see Section 7.1 and Appendix A for examples of accountability for payment)
3. Finally, disaster relief frequently arrives too late. Besides practical reasons for aid not being timely, governments and the international community may wait to see what others give before giving. This strategic delay may reflect a desire for a clearer idea of the burden sharing among disaster relief funders, before making payments7 (see section 3.3 for examples of rapid-payment disaster liquidity products).

Insurance schemes are one way that governments can plan *ex-ante* for climate-driven disasters, and reduce their dependence on donors. Specifically, independent disaster insurance institutions can (and in many places do) allow governments to break the typical disaster relief commitment problem. These institutions need to be able to commit to:25

1. A coordinated plan for post-disaster action agreed in advance
2. A fast, evidence-based decision-making process
3. Financing on standby to ensure that the plan can be implemented.

These commitment devices can allow wider and deeper transparency of decision-making before and during crises, whilst also facilitating the participation of people in robust, inclusive planning processes.[28]

4.4.2 INEQUALITY IN PROTECTION

Through allocating resources, governments make implicit policy choices over whom to help with protection against what. Whilst this may be seen as a legitimate policy choice, this can leave large gaps in coverage, and can end up exacerbating inequalities.[29] For example, poorer herders in Mongolia tend to lose a higher proportion of their herds to the same adverse weather conditions compared with their wealthier neighbors, because they have less access to pasture, campsites, shelter, fodder, wells and veterinary services.[30] However, they are also less likely to purchase insurance from Mongolia's subsidized, but voluntary, index-based livestock insurance program, where 80 percent of subsidies go to larger herders with more than 200 animals. So, in the event of a *dzud*, a harsh Mongolian winter, poorer herders are faced with both higher mortality and lower insurance coverage than wealthier herders.

Depending on its design, agricultural insurance can lead to those excluded from cover, such as landless laborers, going even further backwards after disaster.[31] In the event of a severe drought, for example, insured farmers would have additional purchasing power for whatever food and services are available in the market during the drought. Any such price increase would reduce the ability of the landless to purchase such food or services. The same can be true of other forms of catastrophe insurance, such as prop-

erty catastrophe schemes which only cover titled land or immovable assets, and therefore could leave slum dwellers even less able to afford building materials after a flood. The most vulnerable are in particular need of well-designed government interventions, because they are rarely in a position to either evaluate or afford insurance schemes from their own resources. Hence, governments need to design schemes with protection of the most vulnerable in mind (see Appendix A).[7]

5. Insurance: A mechanism for adaptation within a wider fiscal framework

In this section we position insurance within the wider fiscal framework, showing how governments can maximize the efficiency of insurance solutions by integrating them with other financial measures, and with a comprehensive climate adaptation plan.

Insurance is not a single solution to issues of climate adaptation. Other financial instruments have roles to play, and governments should consider insurance as an important part of a suite of financial measures. An integrated financing strategy can 'mix and match' from the available financial instruments to generate more comprehensive cover across the spectrum of risk; more cost-effective cover; and more timely and practically effective cover.

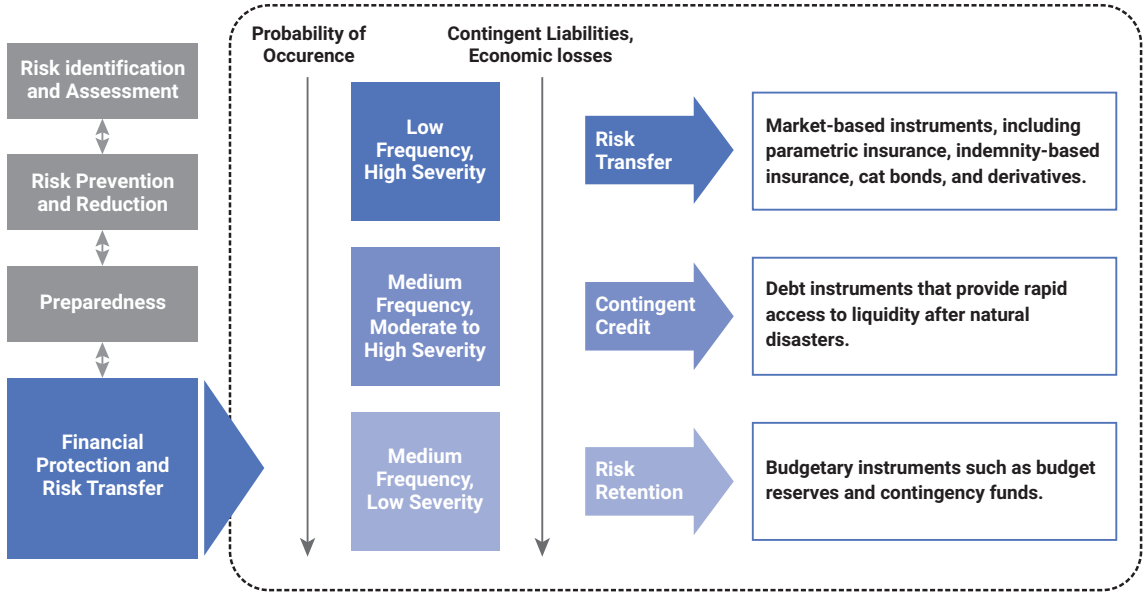
Mixing financial instruments can also give governments the budget flexibility to meet two different objectives: to provide a rapid and effective response to disaster; and to protect the public finances from the enormous costs of disaster. Finally, the right mixture can help countries to reach the widest range of socio-economic levels in their society.[32]

It is therefore important to understand how insurance 'fits' with other financial instruments, within an overall strategy for climate adaptation. This is summarized at a **macro**-level in Figure 2.

The left-hand column of Figure 2 places insurance risk transfer in the context of climate adaptation. Risk identification and assessment is a core expertise of insurance, and the necessary first step in considering physical resilience measures, such as risk reduction and preparedness. These measures reduce the residual risk which needs financial protection, and therefore reduce premiums and make insurance (or other financial instruments) more cost- effective. However, risk transfer can also support and incentivize action on physical resilience, such as the building of flood defences, or the development of early-warning systems for drought (see Section 6).

The key function of insurance is to provide financial protection against risk. The central column of Figure 2 shows climate risks on a spectrum of frequency and severity. For example, in some regions, localized wildfires occur practically every year, but the total losses may usually be relatively small. In other regions, a catastrophic tsunami may only occur once in a hundred years, but (as in Japan in 2011) kill thousands, and destroy or seriously damage more than a

FIGURE 2 Macro-level climate risk finance instruments[32,33]



million buildings. In Figure 2 the probability increases down the column, the severity increases upwards.

As we indicate in the right-hand column of Figure 2, a broad spectrum of financial instruments can help governments address these different risk levels.[33] Such a layered approach to climate and disaster risks can help governments identify which financing strategy might provide best use of capital. For instance, in the case of frequent but low-severity wildfires, a government might maintain a contingency fund year-on-year, thus retaining the risk. For the small probability of tsunami, various risk transfer products will probably be most cost-effective.

However, choice of financial instrument is not simply a matter of how severe the event will be: it also depends on the protection needs that the government wants to address. It might use parametric or index-based products to provide rapid, timely funding for disaster relief after a climate event, and indemnity-based insurance to fund reconstruction (see Section 3). The government's financial resilience is improved by using both. As illustrated in the Figure, **insurance** can be complemented by other **risk financing** instruments to address risks in lower layers.

The use of risk transfer products also feeds back into climate adaptation strategy. A government purchasing a disaster liquidity product knows that money will quickly be available in case of disaster, and can accordingly plan and budget its response systems much more specifically. Countries may be drawn together into risk pools (see Section 2), such as African Risk Capacity (see Section 6) because risk pooling drives down the cost of insurance, and subsequently develop a joint expertise in early-warning systems.

On a **micro**-level, insurance provides direct financial protection for lives and livelihoods affected by disaster. As explained in section 4.1, where private insurance markets fail to offer insurance cover affordable to large sectors of the population, government-led programs can act as insurers of last resort. These may seek to engage private insurers in various ways, include some provision of capital, or design of the products, or as distribution channels for payouts. They can also tie payouts to general policy on risk reduction, thereby reducing risk levels to a point where private insurance comes back to the market. Government can also develop policies and shape regulatory frameworks for sustainable meso-insurance products. For example, as in the Kenya livestock programme (see section 3.3.1) they may pay for the development of micro-insurance products for poor farmers with very specific circumstances and needs. In such cases the development expenditure may not generate enough commercial return to be viable for a private insurer, but the private insurer can be a partner once the micro-insurance product is established. The government can also ensure that climate-risk preparedness and reduction behaviours are incentivized in line with its broader climate adaptation strategy.

Insurance risk transfer and other risk financing solutions should therefore be embedded into macro-fiscal frameworks and given budget allocations with guidelines for their implementation; all within national policies for both disaster management and climate adaptation. Climate adaptation strategies should promote the sharing of insurance expertise, and ensure that specific insurance solutions for financial protection also incentivize risk reduction and preparedness.

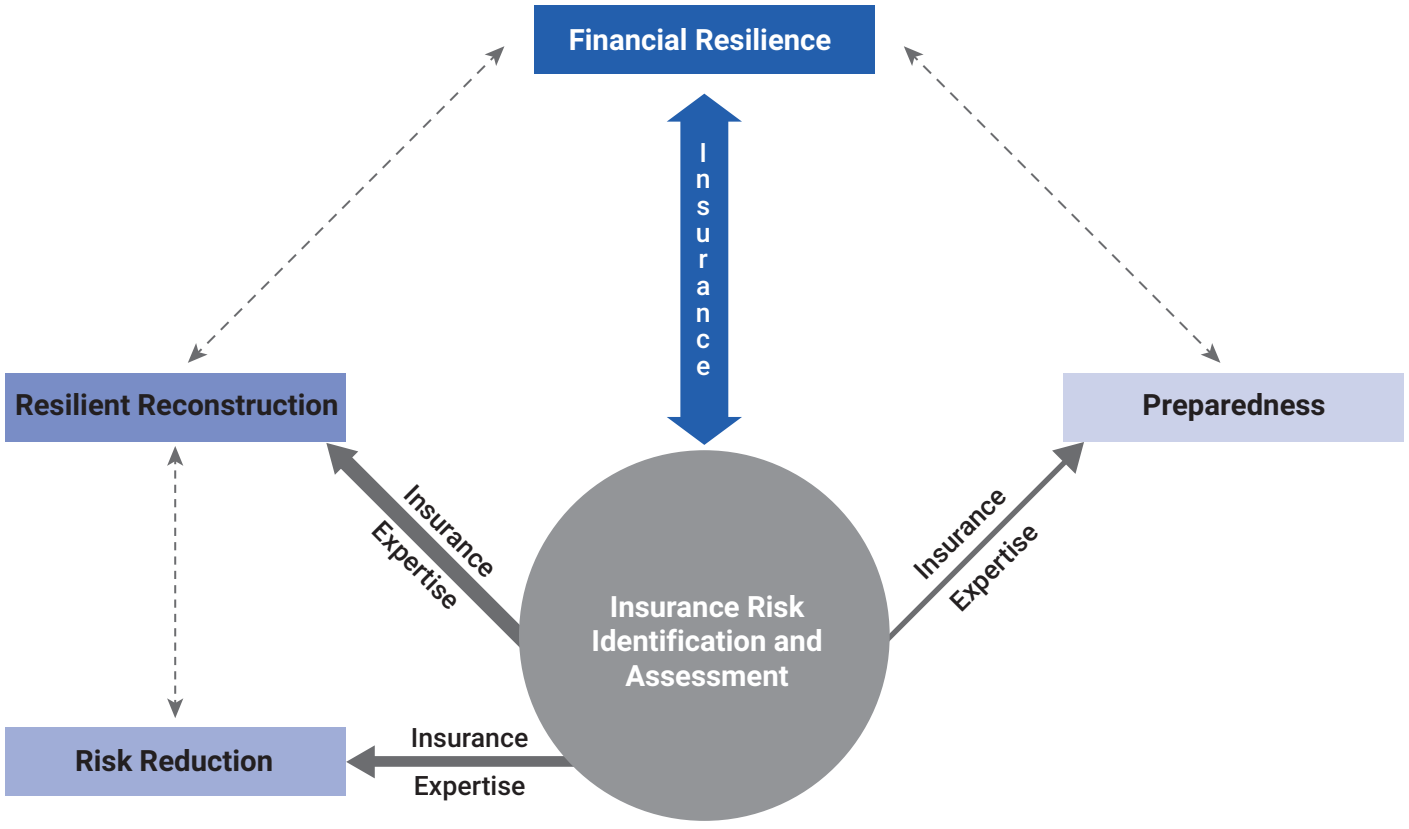
6. Insurance for climate change adaptation: The opportunities

Building resilience to disasters[34,35] is key to climate-change adaptation. Insurance can be an important tool for adaptation as it is strongly linked, in several ways, to disaster resilience in society. First and foremost, insurance provides financial resilience, the capital to support response and recovery. Financial resilience minimizes the impacts of disasters and provides financial stability to insureds in their aftermath. However, if it leads purely to reconstruction of what was destroyed, without doing so in a manner more adapted to climate change, then the underlying vulnerability remains unchanged. Here, we present an Insurance Resilience Framework, to show how insurance can support not only financial resilience, but also other activities essential to climate change adaptation, including risk reduction, resilient reconstruction and preparedness.

6.1 Identifying climatic risks

The process of generating an insurance product involves the identification and analysis of risks, typically through rigorous modelling, (see catastrophe models in section 2.2). This central function in the generation of insurance products is indicated in Figure 3 by the thick arrow between financial resilience and risk identification. At the same time, risk identification is one of the first steps in disaster resilience. The risk identification expertise of the insurance industry can also be of great value for local communities and governments, particularly when the insurance industry engages with emerging markets, where such data or approaches to risk have previously not been considered. Insurance companies that share risk information and

FIGURE 3 Insurance resilience framework (adapted from the World Bank 5 pillars framework)[36]



expertise can help countries and local communities to better identify specific climate-change-driven risks against which they may be able to make adaptations.

Countries and communities with limited resources and low income usually also have low insurance penetration, and do not have a sophisticated identification and register of risks. The development of risk information and modelling in such countries is often only stimulated by serious consideration of insurance either by governments, development agencies, or insurance companies seeking a new market. For instance, after working with ARC, the government of Ghana was able to develop contingency plans for identified risks, even though they did not eventually buy an insurance policy. Thus, risk identification enabled by insurance can build critical mass for resilience planning and stimulate action for climate change adaptation beyond the narrow mechanism for financial resilience through payouts. The search for a financial solution drives the coordination of existing data and models and the development of new ones, as shown in Example 2.

Risk-modelling expertise enables both risk pools and their government members to understand and quantify the natural hazards that pose the risk of disaster, the exposure to the natural hazard, and ultimately the level of vulnerability of communities to a potential disaster. This modelling expertise, if effectively shared with other resilience-generating stakeholders such as governments, (inter)governmental organizations, and other bodies at the local community level, can then inform adaptation measures. It should influence decision-making and policy about areas of unsustainable development, improving resilient reconstruction, and enhancing preparedness for disaster, as we indicate below.

6.2 Signaling unsustainable development

The sheer amount of available data on risk exposure of property, particularly in mature insurance markets, combined with improvements in risk modelling, has resulted in more granular, personalized pricing of property premiums. Properties that are most exposed and vulnerable to loss

EXAMPLE 2

In 2004, Hurricane Ivan devastated the Caribbean island nation of Grenada, and caused heavy damage in other countries including Jamaica and the Cayman Islands. Recognizing that they were all highly exposed to similar hazards such as tropical cyclones and earthquakes, the twenty countries of the Caribbean Community (CARICOM) approached the international community for help to manage financial elements of their disaster risk. With technical leadership from the World Bank, a multi-sovereign risk pool, the Caribbean Catastrophe Risk Insurance Facility (CCRIF), was proposed to transfer some of the risk of disaster into global reinsurance markets. Collectively, each of these relatively small countries would benefit from shared technical expertise and operational costs, diversification across their member states, and increased reinsurance purchasing power.

However, proprietary insurance models for the region were sparse. First, the pool needed to develop data and modelling capabilities to help members quantify their risk. This would be expensive, as there were no consistent risk registers of public assets across the different nations. The data that did exist was of varied quality and accuracy, in terms of both robust hydro-meteorological observations for the projection of future hazard, and registers of exposed assets from which to calculate possible losses. A Japanese Government grant helped provide scientific expertise, drawing on existing understanding of hurricanes in the Caribbean, to quantify the exposure to hurricanes and ultimately the level of vulnerability of the member states' assets to a potential hurricane disaster. These data, combined with a novel proposal to provide disaster liquidity products based on parametric triggers, provided the basis for ongoing risk identification. This information could then be used for a range of other risk-management purposes, such as strengthening resilience through flood mitigation initiatives, and disaster prevention improving disaster prevention awareness at the community level.[37] The intention to develop an insurance product has provided the basis for a consistent form of risk identification in the region.

from particular hazards can be pinpointed and their policyholders charged premiums that more accurately reflect their specific risks.

Insurance sends a strong price signal that specific risk-prone areas are only viable to insure if charged with a high premium. If an area has an increasing number of properties that are highly priced to reflect their risk, it is likely, as we explained in section 4.2, that it will no longer be economically affordable for people to buy insurance. More broadly, the market signal of high prices can be seen as the prompt to improve risk mitigation in risk-prone areas. Insurers may be able to lower the premiums to these policyholders, if suitable risk reduction measures are taken.

While insurers do not have control over the legislation necessary to change planning permissions over where to build, or construction regulations on how to build, they can nonetheless use the price signal to influence risk reduction in different ways. First, insurers can, and often do, reward individual risk-reduction behaviors by reducing policy premiums. Second, such pricing signals can enable or motivate governments to implement changes in planning permission and policy over land-use planning and building codes for high-risk areas (see Example 3 below). Third, increased premiums or even unwillingness to insure properties in a region at high-risk can motivate or force a government to reduce risk in the natural or built environment for a whole region (see Example 4 below). Even for vulnerable communities, where there are few building codes or land titles, insurance can still be linked to improved resilience at the policy level and also, as with the R4 initiative, can support community resilience measures at the micro- or meso-level. These activities can lead to strengthened physical resilience beyond the financial resilience achieved through insurance payouts: for example, through the improved resilience of critical infrastructure or the restoration of ecosystems as resilience-building barriers. In addition, the ongoing insurability and loss history of an area, after the implementation of resilience measures, can help to quantity the benefits of such climate adaptation activities and encourage further such initiatives.

EXAMPLE 3

The Texas Windstorm Insurance Association (TWIA) has influenced mitigation measures for houses and other low-rise buildings by requiring that they meet appropriate weatherproofing specifications. A Texas Department of Insurance (TDI) windstorm inspector visits buildings to ensure compliance with TWIA building specifications and, if the standards are met, a TDI Certificate is issued. While the Certificate is not mandatory in order to buy or sell a house, prospective buyers now have an expectation of TDI Certification when viewing any property. Mitigation against windstorms is thus incentivized via insurance in Texas.

Adapted from McAneney, J., McAneney, D., Musulin, R., Walker, G., & Crompton, R. (2016). Government-sponsored natural disaster insurance pools: A view from down-under. *International Journal of Disaster Risk Reduction, 15*, 1-9.

EXAMPLE 4

In 2012 the Suncorp Group, one of the largest general insurers in Australia, withdrew from offering and renewing policies in the Queensland towns of Roma and Emerald. This withdrawal, that lasted for 16 months, came after Suncorp reported paying AU$150 million in claims in return for AU $4 million in premiums after these towns flooded three times in two years.[i] The decision brought about a rapid response on the part of government, in the construction of levees to reduce the risk of flooding. After these risk mitigation measures were implemented, insurers returned to offering policies, now priced affordably to reflect the reduced risk of flooding. While it is true that this example worked within an area where there was one dominant insurer, high local awareness of the threat, and a specific means of reducing the risk, it nonetheless shows how insurers can exert market pressure and work with governments to enable risk mitigation measures.

Adapted from McAneney, J., McAneney, D., Musulin, R., Walker, G., & Crompton, R. (2016). Government-sponsored natural disaster insurance pools: A view from down-under. *International Journal of Disaster Risk Reduction, 15*, 1-9.

i See http://insurancenews.com.au/local/suncorp-quits-flood-towns-and-calls-for-mitigation-action.

6.3 Preparedness

Disaster preparedness, involving early warning systems and contingency planning, can be encouraged through the use of catastrophe models in insurance. An insurance company may have the data to indicate the likelihood of loss, allowing it to build understanding of how to prepare for a disaster, but may not have the power to enforce active preparedness steps. The company can suggest and incentivize better ways for their policyholders to prepare for disasters, for example, via preparedness guides and checklists, that can potentially help reduce the risks to them and their properties. For example, hurricane warning systems use communications via some or all of television, radio, social media, mobile text-alerts, and more, to warn residents to deploy storm shutters on their windows. Of course, such alerts are only of value where people have the financial and physical capacity to act in response, and where there are coordinated systems to facilitate those responses, such as evacuation plans in preparation for a disaster. Importantly, these preparation systems can specifically link insurance to contingency plans for addressing disaster, as our Example 5 shows.

EXAMPLE 5

A key feature of the way ARC inducts its member states is to take them through a process of risk modelling. This is used as a basis for designing early warning systems for impending disaster from drought, and to undertake contingency planning for how, specifically, they will use any payouts to address the disaster. All this work is done before the country might take out the risk-financing component of membership. The establishment of such risk preparedness procedures in ARC is helped by the fact that most of the scheme deals with drought, a slow-onset disaster in which the impact can be observed, and targeted responses enacted as the disaster worsens. In addition, the payments are intended to support food security, for which, again, there can be contingency planning in advance. Preparedness for other types of risks, where onset is more rapid, may be different. Nonetheless, some early warning systems, and other preparedness measures, may be adopted as a spillover effect from the risk modelling and identification enabled by insurance.

Preparedness need not only be physical but can also include improved financial planning and preparation. Better understanding of hazards and associated vulnerability can enhance financial preparation for disasters by allowing governments to better assess the economic costs of disasters, and how these impact different ministerial budgets. Such planning may in its turn support the design of new financial products to complement and extend the relief provided by insurance products.

An example is forecast-based financing (FbF) – a mechanism for releasing humanitarian funding triggered by a pre-established forecast threshold. The goal of FbF is to anticipate disasters; to prevent their impact, if possible; and to reduce human suffering and losses. A key element of FbF is that the allocation of financial resources is agreed in advance, together with the specific forecast threshold that triggers the release of those resources for the implementation of early actions. The roles and responsibilities of everyone involved in implementing these actions are defined in a protocol that ensures the full commitment of implementation among the involved stakeholders.

FbF has been piloted by the Red Cross Society in villages facing a high risk of flooding in Peru, Togo, Uganda, Bangladesh, and Mongolia.[39] It uses weather and climate science to anticipate possible impacts in risk-prone areas, and to mobilize resources automatically before an event.[40] For instance, building on Togo community-based early warning systems, Red Cross has developed a flood-risk forecasting tool called FUNES, to trigger early preparedness action and to release funding necessary for rapid risk reduction before the flood hits. FUNES is a catastrophe model which uses a self-learning algorithm to predict flood risk in the populous Mono River basin. The model integrates three sets of data: flow data entered daily by dam operators; upstream rainfall readings, transmitted by observers using SMS; and actual flood impact data, entered each year by Togo Red Cross. The result is a model specific to the local communities at risk, which generates increasingly accurate forecasts of flood impact, allowing

identification of trigger points at which financing should be released - hence, forecast-based financing.

However, such forecasting could also be supported by already-available insurance triggers. For example, satellite data can now be used to forecast drought based on greening measures (see the Kenyan livestock insurance program, Section 3.3.1), in order to put in place humanitarian aid and preparedness strategies before catastrophe occurs.[41] While some promising entry points exist for linking flood forecasts with FbF, this technique is relatively new and not widely tested, and has not yet gained significant ground. Rapid mobilization of funds enabled by FbF can reduce disaster impacts, but in order to be effective it needs significant research and development on trigger thresholds, trigger processes, and payout distribution processes. It also needs further scaling up and stronger links with disaster risk reduction and climate change adaptation strategies.

6.4 Building Back Better: Resilient Reconstruction

Building Back Better is a philosophy which integrates risk reduction into reconstruction after disaster. It sees the disaster aftermath as an opportunity to improve resilience and revitalize livelihoods, economies, and the environment.[42] For instance, buildings can be reconstructed to better withstand future climate risk; but they might also integrate climate-smart technology such as remote sensing. Ideally, improvements in physical resilience would be planned for the potential climate changes over the building's lifetime – probably a matter of decades. This requires a far-sighted approach to construction regulations in general, to 'future-proof' all new building against climate change.

Build Back Better as a philosophy therefore needs good forecasting of climate change, and thereafter, stringent government policy consideration to improve construction codes. Those codes must reduce risk and improve climate-change resilience, but they should also improve sustainability by lowering greenhouse gas emissions. Insurance expertise in risk assessment and evaluation should be included in that policy consideration, both for itself, and because risk reduction makes insurance more affordable and cost-effective. If reconstruction is to be financed by insurance payouts, the payouts then need to reflect the necessary improved building standards.

Climate-change forecasting is beginning to happen, but it is patchy and local, rather than global. Admirable initiatives have been taken in South Africa, which recently developed a 'Greenbook' projecting a range of climate change scenarios to 2050,[43] while the Australian Actuaries Climate Index[18] was launched in 2018 to help Australian policy-makers and businesses to incorporate increasing climate risk into their decision-making. However, neither yet gives a level of detail which can support such (re)construction policy, let alone suggest how insurance cover could be priced to allow the cost of resilient rebuilding.

The post-disaster setting is a complex and demanding environment, and not a good place or time to start a fresh conversation about rebuilding standards.[44] Insurance is best integrated into a Build Back Better approach through pre-arranged, *ex-ante* recovery and reconstruction plans that account for climate-risk management. Involved insurers could further incentivize Building Back Better, by applying pre-determined premium reductions when the insurance policy is resumed after resilient reconstruction.[45] For example, reinsurers have been working with FORTIFIED (a program by the US Institute for Business and Home Safety) in the USA to promote reconstruction to a superior (voluntary) set of building standards after insured homes have been affected by natural disasters.[46] At the household-level, insurers can work with FORTIFIED-linked civil engineers, construction companies, and public initiatives to offer services and products that support resilience.

Insurers should be invited onto working parties containing all the government departments concerned with development planning, so that insurance can inform decision-making around risk-reduction and resilient reconstruction.

7. Insurance for climate change adaptation: The challenges

For insurance mechanisms to maximize their support for climate change adaptation, it is necessary to take a realistic look at the significant barriers that prevent their effective use. Barriers often stem from complex negotiations across different types of public and private stakeholders, a relatively low understanding of insurance mechanisms, and the need for insurance to be integrated both into a comprehensive suite of connected adaptation practices, and into the broader development agenda. In addition, insurance is a very specific type of financial solution, that itself needs some innovation and adaptation in order to address the implications of climate change. These innovations will need to be implemented within strict financial controls to ensure the relevance of products to cover climate-related risk, and the solvency of insurers to pay for them. In this section, we will discuss the limitations of, or barriers to using insurance in climate adaptation.

7.1 Increasing insurance penetration: Bridging the protection gap

As we noted in our introduction, despite increasing insurance innovation, the protection gap remains significant. While insurance can be an important mechanism for climate adaptation, it needs to be adequately spread to relevant sections of society in order to have positive effects. Density of insurance penetration is critical to a society's ability to recover post disaster.[17] Those countries with higher insurance penetration recover faster after a disaster, as quick payouts lead to faster reconstruction. In combination with a technology upgrade, such rebuilding might even stimulate economic development and boost GDP. By contrast, insurance penetration in low-income countries usually falls below 1%. For example, Madagascar, one of the poorest countries in the world, has an insurance penetration of 0.2%. Economic shocks and extreme events constitute a huge burden and make the country highly vulnerable. The poorest people are particularly vulnerable as they have few financial coping strategies; they depend on humanitarian aid.

The reasons for low insurance penetration, even in relatively wealthy countries, are complex. One reason lies in human beings' cognitive biases around low probability-high loss events, meaning that potential insureds – not only individuals, but also government actors – ignore the very real threat of disaster on the basis that it is so unlikely, that it will not affect them. This cognitive bias is often compounded by cultural barriers to insurance, for instance in countries where disaster has either been seen as a matter of 'fate'[48] or as something for which compensation is the government's responsibility. In such contexts, especially where there are few success stories about how insurance has transformed people's lives, it is difficult to generate understanding of insurance or increase its penetration. Insurance as a form of ex-ante preparation for disaster puts an onus on those who will experience it, to take some responsibility and seek protection from that disaster. It requires forward planning around the probability of disaster; and considerations about how those under threat might afford the losses they will experience, and about the mechanisms, including insurance, that they and their government might use for protection. As we note in section 7.4 below, at least some of this responsibility can be encouraged by increasing financial and risk literacy across society.

The protection gap can also be associated with lack of availability or affordability of insurance products. Reasons for this lack range from insufficient reinsurance capacity for insurance companies to remain solvent in high-risk areas,[49] to insurance companies increasing premiums to reflect high risk of disaster.[50] As noted above, improved modelling has led to higher premiums for those at most risk of disaster and these assets defined as high-risk are actually growing, in part due to socioeconomic growth in high-risk areas, in part due to increasing frequency and severity of disaster arising from climate change.[51]

Other studies suggest that a lack of information and expertise about how to model under-insured areas or types of risk contributes to the protection gap.[52] In particular, designing suitable products for the risks from which vulnerable people need or want protection can be challenging, necessitating innovations such as the index-based products we discussed in Section 3.2, as well as considerations about who will pay for these products. Another fundamental problem, as we noted in Section 4, is that much risk remains uninsured because it has poor economic viability within a traditional market value chain.[5,53]

As a recent report shows, many of these protection gap challenges can be addressed through the establishment of

a well-designed Protection Gap Entity (PGE), such as a sovereign risk pool.5 PGEs can support risk sharing between the public and private sector in order to bridge the protection gap, meanwhile evolving their remit in response to the changing risk profile associated with climate change.[54] Caisse Centrale de Réassurance (CCR) in France and Consorcio de Compensacion de Seguros (CCS) in Spain are examples of publicly-owned (re)insurance institutions that support high levels of insurance penetration across the population.

In addition, where insurance is a suitable product to protect the most vulnerable from disaster, but is beyond their means to purchase, such PGEs can be the vehicle by which insurance can be subsidized. Many individuals lack the disposable income to purchase an insurance product, and many low-income countries have such constrained budgets that insurance is beyond their resources. Here the question of subsidized premiums needs to be considered as a development tool. Insurance is linked to risk ownership, and so subsidized insurance, in which the risk owner does not pay the premiums for its protection, comes with concerns over moral hazard. Similarly, donors and development organizations may be reluctant to subsidize premiums on the basis that such money should be used within a country, rather than paid to insurance markets. However, many PGEs are publicly-owned and/or operate on a not-for-profit basis with the aim of using insurance as a means of enhancing social inclusion. In such situations, where a donor pays for the premiums, a well-designed PGE can be accountable for the ownership of the risk and the use of subsequent payouts to support disaster relief, and, if provided in the product, recovery and reconstruction.

It is a complex task to design PGEs that enable knowledgeable ownership of risk, and accountability for distributing payouts. In Appendix A, we outline the extended formal process that member countries of the African Risk Capacity (ARC) have to go through in order that payouts can be linked to targeted response activities. While donors or policy-makers may call for such strong links, it is important to understand what is required to get this done in terms of process, operation and governance. In order to ensure that indeed payouts do get to the most vulnerable households, it is necessary to structure effective public policies for responding to disasters in advance. This includes identifying both levers to support, and barriers that might constrain the administration and flow of funds through government systems: from a central Treasury to implementing agencies and thence to beneficiaries. Development of such policies is extensive, administratively heavy, and, if ex-ante contingency planning of this nature is a requirement to become a member of a risk pool, may actually delay pool growth and eventually risk its survival.

On the positive side, the process of developing such public policies for targeting insurance payments to the most vulnerable after a loss can be an effective learning experience, enabling tracking of existing public financial systems, and their linkage to disaster response systems.

7.2 Enhanced risk reduction

Insurance, while it enhances the financial resilience of society to disaster, is not a silver bullet. Increased insurance penetration is not enough to address climate adaptation unless it is connected to enhanced risk reduction. In particular, in areas where disasters are both frequent and severe, such as those with annually repeated flooding or drought, risk-reduction measures are necessary before insurance can be an affordable solution. As we noted in Section 6.2, insurance can be a price signaling mechanism indicating, through higher premiums, that an area or assets have insufficient risk mitigation measures. However, risk reduction rarely falls within the scope of an insurance mechanism, except as a pre-condition to the provision of a policy.

Government departments and insurers must work across siloes to ensure that risk transfer promotes and even incentivizes risk reduction, and enables change in the physical aspects of resilience. As we showed in the example of TWIA in the USA (Section M.N.O), insurers and policy-makers working in close consultation can change building regulations in order to make properties more resilient – and thereby, more insurable.

Insurance can strengthen planning and minimize future costs of climate risks. However, if insurance is used as a blunt financial instrument to increase capital flow after disaster, it can actually be detrimental to resilience measures. For example, government schemes that suppress pricing signals, or parametric insurance that is not linked to paying for actual loss, can limit incentives to mitigate risk. Likewise, risk finance and insurance decisions on macro-fiscal levels are usually taken by the ministry of finance without engaging, for instance, environmental, transport or infrastructure ministries, that could ensure better alignment

with risk-reduction measures. If we are to take the association between climate adaptation and insurance seriously, we also need to see how changes in the natural and built environment will reduce exposure to risk – and we need to think deeper about the sustainability of building in locations signaled to be at increasing risk of disaster.

This issue of reducing risk is of vital importance to enable a significant proportion of a population to benefit from the security provided by affordable insurance. Yet the socio-political context in which insurance is joined to risk mitigation and risk reduction is often fraught. There may be complex negotiations between multiple stakeholders with different interests in, and understanding of, risk cover, and with different levers of control over risk mitigation decisions. We suggest that, where governments and development organizations support the establishment of insurance-based mechanisms to increase financial resilience, they also tie such development to improving the physical resilience of a country, including apportioning budget towards efforts at risk reduction. For example, Clarke and Dercon (2019) propose a 'development bancassurance' model, where development banks and development insurers work together on an integrated package for countries.[28] Development banks would finance the pre-crisis expenditures such as on prevention, preparation, and risk information, and development insurers would finance the crisis-contingent expenditures. These efforts to join the financing of risk reduction to insurance would have benefits at micro-, meso- and macro- levels in making insurance products more sustainable. In doing so, insurance can be part of the wider fiscal framework and physical planning necessary to support the virtuous circle of both *bridging financially*, and *reducing physically* the protection gap.

7.3 Balancing short-term insurance products with long-term adaptation measures

While climate adaptation involves forward-looking measures to improve the resilience and sustainability, insurance as a product is designed around short-term protection of assets. Most of the products we have discussed in this report operate on the basis of a 1- to 3-year renewal. When the policy comes up for renewal, the premium may decrease if, in the interim, the assets have been better proofed against climate-related shocks. Essentially, insurance is a reactive product to the adaptations that have already taken place, rather than a proactive product to support that adaptation. At this stage, the annual life-cycle of insurance products for physical assets is not directly linked to, and supporting, longer-term climate adaptation.

There is evidence for the increasing use of multi-year contracts for physical assets, particularly catastrophe bonds, which typically have a 3- to 5-year duration. However, multi-year contracts of sufficient duration to cover a climate adaptation window, of, say, 10 years, would be challenging to implement under a regulatory framework that also demands solvency from insurers. Specifically, to ensure they could pay claims against a long-term and uncertain risk future, insurers would need larger capital reserves. These would need to be built into pricing that would make the cost of premiums prohibitive. Maynard & Ranger (2012) model various long-term insurance products against adaptation scenarios to show that, even for risks that remain stationary over the period, the capital requirements for insurers could be some 50% higher for a 10-year contract than an annual contract. This would increase further in the context of uncertain and changing risk profiles such as those associated with climate adaptation.[55] Such capital costs would be passed on in premiums, making the product less affordable to potential policyholders.

Insurance innovation is thus needed. However, this must be done thoughtfully, and with attention to the reputability of insurance as a promise of payment. It is important not to over-claim, or over-extend the capacity of insurance as it currently stands to provide for climate change. Insurance needs to price risk in ways that reflect the true costs of paying claims, in order to ensure solvency, and risk transfer should be used within a strong regulatory framework for ensuring such solvency. Furthermore, while reinsurance is one means by which insurance companies ensure solvency, reinsurance capital worldwide has limitations in withstanding large climate shocks within a specific region. Reinsurance capital will need supplementation from other risk-financing products, as well as tight integration with the wider risk-reduction measures noted in Section 6.2.

7.4 Financial and risk literacy

While there is increasing evidence that insurance supports productivity, growth and social inclusion[56] significant challenges impede the ability of the industry to deliver on its full potential.

One particular challenge arises in emerging markets, where insurance is often viewed as a luxury rather than an essential aspect of development. This is just one example of a general lack of the technical risk understanding and insurance literacy which should inform a more resilient development agenda. Ultimately, a better understanding of risk and insurance will drive the development of fit-for-purpose innovations that are needed to tackle the issues that many across the globe contend with, be it at the macro-, meso- or micro-level. For example, risk assessment and analysis could quantify the decrease in future risk that arises from better enforcement of building codes, and hence demonstrate the benefit of spending additional funds on building code enforcement (see TWIA example, Section 6.2). The unfortunate reality however, is that right now, decision makers are not fully accessing the range of insurance solutions, products, and approaches available to them, and which are an essential consideration for adaptation to climate change.

The development of risk and insurance literacy is important for many reasons, which include:

- **Improving the capacity to identify risk:** Identifying risk is a fundamental first step in seeking to manage it. Risk assessments are central to the functioning of insurance markets both in their ability to underwrite and provide financing solutions and in driving better risk-management actions and decisions. Modelling techniques and approaches developed by the industry over the years have played a critical role in building resilience (see CCRIF example, Section 6.1).

  However, in many countries, an absence of a coordinated and central approach to understanding risk remains a significant challenge. Risk assessment programs and activities are outsourced in many countries, as part of ongoing projects, rather than being built in or mainstreamed into government processes, so missing opportunities to enhance such capabilities within government departments.

  Climate change deepens the problem of this lack of built-in government expertise. Risk will evolve both in timescale and geography, and further urbanization and development is likely to increase exposure. The ability to track and assess these evolving risks, across all social groups and economic activities, is vital to drive a new wave of climate-sensitive public policies and investments which will help society to avoid, mitigate, and adapt to such risks.

- **Shared analysis and dialogue around risk is essential for developing inclusive responses:** Risk and its management are inherently political, with vested interests, institutional competition and administrative bureaucracies which are often in competition and sometimes cross-border and which can impede coordination and cooperation efforts.5

  Establishing mechanisms that allow for a shared and inclusive dialogue around risk will be essential for effective adaptation. Insurance enabling tools, such as risk models, often prove to be an entry point for objective discussions around risk and initiating the identification of possible solutions and requisite responsibilities for managing the risk.

- **Awareness of the pros and cons of the different tools available to manage risk:** Risk management needs to be based on active considerations around tradeoffs and opportunities for efficiencies. Resources are not unlimited. Many in the public sector recognise that, to prioritize their efforts, they need greater awareness of the pros and cons of the different options available for managing climate risks, and importantly, the tradeoffs that each of them might need.

- **Allocate responsibility and ownership of risks within the broad policy framework:** Once a risk has been identified and different tool available for managing risk have been accessed, the next critical phase is identifying responsibilities for managing the risk. Clearly-ascribed ownership of a risk increases the possibility of that particular risk being better-managed. Without this, investments made will be ad hoc and fragmented. Such ownership is also essential for sustainability and driving the development of policies and financing need to manage the risk. With climate change, this need is amplified with scarce resources increasingly coming under pressure and a need for more efficient expenditure.

Risk literacy and an associated understanding of insurance and the suite of tools offered, presents an opportunity to support these deepened considerations around how governments may drive their climate adaptation efforts in the short, medium and longer term. Such deepening of knowl-

edge about insurance and its value is particularly critical in developing economies. In developed economies, insurance is already an established pillar for development. It is built into the system of financial protection without people or governments questioning its relevance. In this context, the industry has not necessarily been required to communicate its value proposition. By contrast, in emerging economies insurance is not financially and culturally embedded into the socioeconomic system of recovery, yet their constrained budgets make the need for such communication particularly important.

Despite this, building risk capacity and insurance literacy is not an easy task. It often takes significant time, involves a multiplicity of actors at various levels, and difficult decisions around investments, all of which can be at odds with political timelines. Building a culture of risk management and insurance also means investment in generating capability and awareness. The two go hand-in-hand.

7.5 Insurance as a local solution to a global problem

Climate change is a global problem, yet it manifests itself locally, in many different ways. Commercial, private insurance companies have to invest in a thorough understanding of the local risks and potental clients, then price cover according to the risk of claims for those very specific local circumstances. But for many people in the poorest parts of the world, those premiums would be unaffordable, so insurance companies simply ignore those local 'markets' as uncommercial.

However, development funding can take a more global view to introduce insurance to such areas, thus accessing global (re)insurance capital for the financial protection of the poorest and most marginalized. Development funding might pay for the analysis and modelling of the local risks. It can also work to link the resulting insurance to risk reduction, thus making the area more sustainable, and potentially reducing the cost of premiums. For example, the R4 Rural Initiative by the World Food Programme and Oxfam offers micro-insurance specifically linked to risk reduction for smallholder farmers in Africa. R4 was initiated in 2011, with the specific aim of making vulnerable rural households more resilient to climate shock. The solutions are locally tailored to the types of crops and assets in local communities in Ethiopia, Kenya, Malawi, Senegal and Zambia, enabling the growth of such assets through risk reduction. The physical risk reduction measures are bolstered by micro-insurance for those assets, which also thus underpins micro-credit and savings plans.

However, not all localized effects of climate change are insurable. As noted in section 7.1, global (re)insurance companies must remain solvent for insurance payouts to be reliable. There may simply not be enough (re)insurance capital to provide in full for the global effects of climate change, even if the world could afford the premiums. Rather, as noted in Section 6.2, insurance can send price signals about the increasing unsustainability of some areas under climate change. Hence, insurance is always an interplay between local adaptation to climate change, and the wider policy dialogues and development agendas which can make local responses more effective.

8. Conclusion

Even in a world that limits global warming to the ambitious 1.5-degree C target set under the Paris Agreement, climate change will severely impact our lives and livelihoods, as well as the natural environment, and irreversibly alter the risk landscape across the globe. A transformative, long-term approach to adaptation will be necessary to secure sustainable development paths, and cope with more frequent extreme weather and natural catastrophes. Using insurance to absorb financial losses related to climate risks is a step away from crisis towards risk management, which strengthens socio-economic resilience under a changing climate.

Thus, we recommend a sequence of actions to benefit from insurance, and better surmount the challenges of climate impact in supporting climate adaptation.

Invest in open-source models that a) provide a long-term view of climate risk; and b) link to insurance solutions. Improved risk data and analysis of the impact of climate change are essential to increase understanding about the risk profiles of different countries, regions, assets and populations. These risk data should enable modelling of the frequency and severity of different climate events, geographic exposure, vulnerability, and potential financial losses. The data should then be modelled according to differing projections of the rate of climate adaptation: in other words, by different estimates of how much the vulnerability of the natural and built environment may have been reduced, over various periods of time. This will ensure that climate risk data, covering both a near-term and long-term view of climate adaptation, can be linked to insurance and the risk-transfer process.[57] Such models should not be proprietary, but rather should be open and widely available. This will ensure that they can be used to support public and private insurance mechanisms, including the piloting of insurance innovations, without the pressure to recoup costs from commercial transactions. Hence, we need investment in analytics and in academic research institutions in order to service the collaborative design of climate risk models. Such risk modelling needs to crowd in the best science, drive innovation, and raise the standard of understanding of climate risk at all levels of society. It should thereby leave a legacy of open data and information that supports broader climate-risk management for governments, firms and people. This will enable innovative and cost-effective insurance solutions for today and in light of future climate adaptation.

Joined-up policy-making: Put climate-risk models at the heart of national adaptation strategies. Risk data and modelling helps to inform policy-makers on hazards, exposures and vulnerabilities within their country. They should inform prevention, risk reduction, preparedness, and consideration of risk transfer. A national climate adaptation strategy informed by risk modelling should integrate all of these aspects of resilience, linking, for example, financial mechanisms with risk-reduction efforts. It should also relate adaptation to development initiatives. For example, linking disaster-risk finance and insurance instruments to the nationally determined contributions (NDCs) and national adaptation plans (NAPs) could identify how to best capture resilience dividends. For this to happen we need joined-up policy-making between treasury, environment and disaster-management divisions within government. These divisions must also work collaboratively with development agencies to put climate risk data at the heart of national adaptation strategies. Such joined-up policy-making will support essential innovations, such as the bancassurance model (see Section 7.2), in which development banks promote the development and application of risk information, risk reduction and preparedness measures, thereby enabling insurers to price the risks, and supplement the financing of post-disaster recovery and reconstruction with their capital.

Develop consistent climate adaptation regulation and standards across countries. In order to implement effective national and cross-border use of risk financing and insurance instruments for climate adaptation, common standards and a consistent regulatory framework are needed. This will require supra-national actors, such as the International Monetary Fund (IMF), to establish standards that anchor 'climate and disaster risk finance and insurance' (CDRFI) into macro-fiscal considerations. An international standard for risk finance in macro-fiscal frameworks would be an effective way to trigger action at governmental level. Governments need to take a proactive approach to climate-change-driven risk in their budgetary and fiscal cycles. The inclusion of national climate-risk management measures that comply with agreed supra-national reporting standards could help foster this proactive approach. In

addition, a systematic supra-national approach to the regulation of insurance markets, to which individual countries adhere, will be necessary. Appropriate regulation ensures that climate-related insurance is safe for the consumer, in terms of ensuring both appropriate conduct by insurers, and that they will be able to pay claims and won't all file for insolvency after a large disaster. Consistency across countries is important as sound climate-risk insurance typically requires an appropriate balance between retaining risks in-country, and transferring to globally diversified international markets.

Foster insurance innovations that can respond to a changing climate risk landscape. Insurance innovations need to incorporate a dynamic, long-term, and adaptive view of risk into modelling and pricing. Digitalization, including big data and machine-learning algorithms, has the potential to substantially increase the impact of risk finance and insurance on resilience. Applications should include the improvement of risk analytics and modelling, more accurate forecasting capabilities to promote early action, development of more sophisticated triggers for more effective and reliable parametric insurance coverage, and speeding up claims' settlement and payouts. Development agencies, intergovernmental organizations, and donors, can support the development of these innovations for the benefit of adaptation. In addition, in order to overcome challenges around affordability and access, it will be necessary to create risk-sharing partnerships, and incentives to attract private sector investment into countries in need.

Strengthen dialogue between insurers and policy-makers around Build Back Better. The construction of new public and private assets should consider long-term trends in climate risks, and lower greenhouse gas emissions related to the construction and operation of these assets. Climate adaptation policy should therefore drive new building codes that are focused improved resilience and sustainability criteria, and which are mandatory for reconstruction efforts after disasters. Insurance innovations should then focus on incorporating this Build Back Better approach into the pricing of indemnity products, potentially going beyond the value of the damaged assets.

Converge insurance, humanitarian and development agendas. Developmental and humanitarian efforts must be connected effectively to financial systems, integrating all lines of defense around the risk-management cycle. Public–private partnerships are needed to ensure that the risk capital and expertise of the insurance industry are made available in products designed appropriately and channeled towards the poorest, the most vulnerable, and the marginalized. Collaboration and stakeholder engagement will be essential: insurance needs to further research and possibly rediscover the needs of these parts of the population, while governments and development organizations must promote business opportunities for insurance to invest in 'bottom of the pyramid' markets. In addition, subsidization of insurance for the most vulnerable must be considered, in order to include them in the greater socio-economic stability that insurance provides.

Promote and invest in risk literacy throughout society. Investment to build capacity in risk literacy is not simply about making people (in all parts of society) better able to use insurance mechanisms and tools. Rather, we emphasize that risk literacy, and thereafter insurance, support: (i) the provision of **essential information** for decision making; (ii) mechanisms through which public policy processes, policy-makers, and insureds can objectively engage around considerations of risk; and (iii) prudent and effective decisions by policy-makers, and the establishment of necessary systems and rules to manage risks actively in the short, medium and longer term. By investing in widespread risk literacy, we make possible the range of other recommendations made above.

Appendix: Contingency planning

African Risk Capacity (ARC). Contingency plans: targeting the most vulnerable

To ensure that countries are able to deploy ARC payouts quickly and efficiently, the ARC has adopted, as part of its governance and operations, specific criteria and standards that countries must meet before they can enter into an insurance contract with ARC Ltd. These criteria also serve to ensure that insurance payouts are proactively linked to responses focused on the most vulnerable households and communities.

Countries considering securing insurance coverage from the ARC Insurance Company Limited (ARC Ltd) must have a **Certificate of Good Standing (CGS)** granted by the ARC Board in accordance with criteria adopted by its Conference of Parties (**CoP**).[ii] One of the CGS Criteria is that a country must have a Contingency Plan approved by the ARC Board.[iii] The ARC Contingency Plan is comprised of two parts:

1. **An Operations Plan** which includes information regarding the specific country's natural disaster risk profile, risk-transfer parameters, planned interventions, and draft implementation plans for each possible activity proposed for use of a potential payout.
2. **A Final Implementation Plan (FIP)** details information on how an ARC Ltd payout will be deployed after a specific natural disaster event.

The purpose of an Operations Plan is to delineate the use of an ARC Ltd payout in advance so that if a country receives such a payout it will be prepared to use the funds immediately and effectively.[58] Operations Plans take into account existing national systems and are evaluated based on two standards:

1. Do the proposed activities meet ARC's **Basic Eligibility Criteria**?
2. Can the proposed activities be adequately implemented, monitored and evaluated (collectively, the **Implementation Criteria**)?

Basic Eligibility Criteria

Three questions are actively considered in determining if an activity proposed in a country's Operations Plan meets ARC's Basic Eligibility Criteria.

1. TIME SENSITIVE AND/OR CATALYTIC:

a) Time-sensitive activities are those that:
   i) Are made possible through the provision of timely and reliable funds, and
   ii) Are implemented within approximately 120 days of when an ARC Ltd payout is received.

b) Catalytic activities are those that prompt or enable other activities that ensure faster, more predictable and more effective action for the overall response.

2. CRITICAL SERVICES AND IMPACTS:

a) ARC Ltd payouts should not be used for general investment.

b) Activities must aim to support and catalyze critical activities post-disaster. In slow-onset events, this means protecting livelihoods of beneficiaries that would be negatively impacted if they have to wait to receive assistance or face a gap or inconsistency in their assistance. In rapid-onset events, this may include supporting the basic needs of those affected, and/or protecting livelihoods of beneficiaries.

c) The interventions offer the best use of funds within a specific timeframe, addressing the best available understanding of needs.

3. ABLE TO BE COMPLETED WITHIN SIX MONTHS:

a) Activities that will be funded by an ARC Ltd payout should be completed within six months in order to ensure that financial resources are utilized in a timely and efficient manner, capitalizing on the "fast, reliable funds" principle of ARC.

Each activity proposed in the Operations Plan must meet all three eligibility criteria.

ii See the Establishment Agreement of the African Risk Capacity (ARC) Agency, Article 13 paragraph 2 (h & l); and the Report and Decisions of the Second Conference of the Parties of the African Risk Capacity (ARC) Agency, paragraph 9(d).
iii See the Establishment Agreement, Article 15 (k & l).

Implementation Criteria

Once an activity meets the Basic Eligibility Criteria, it is also reviewed to determine whether the activity can be implemented, monitored and evaluated. Activities may be implemented, monitored and evaluated through external partner entities that the country has utilized for past operations. Detailed information on any implementing partners must be provided as part of the Plans.

In all cases, countries are encouraged to seek to scale up existing activities, where possible, in order to guarantee the most efficient use of ARC funds. All partners will ideally be existing partners who have worked jointly to implement programs with the country in the past and, therefore, have been appropriately vetted as part of these prior activities. In the case of a rapid onset disaster response, if partners are likely to be different to those used in normal programming, countries are required to submit pre-signed MOUs with relevant agencies for relief, covering specific program activities.

Each country must provide information on each proposed activity to outline how the activity will meet the Implementation Criteria – including budgets, timelines and information on all entities involved – across five different areas:

1. **Operations** – Countries are required to provide a detailed summary of the activity being proposed and all of the steps that must be carried out to complete the activity, including expedited procurement processes, if any.
2. **Administration and Flow of Funds** – Countries are required to outline how the government will manage an ARC Ltd payout internally and how it will reach beneficiaries as assistance, including in the case of a rapid-onset, accelerated payout scenario.
3. **Needs Assessment** – Countries will need to provide information on existing needs assessment approaches, any changes that would be necessary in the event of an ARC Ltd payout and details on alternative approaches being considered if appropriate.
4. **Targeting** – Countries are required to provide information on how they will carry out targeting of beneficiaries, the expected profile of beneficiaries and categories of beneficiaries, what type of targeting mechanisms and criteria will be used to identify the different categories of beneficiaries, and how they will ensure that the appropriate assistance reaches the intended beneficiaries in a transparent manner with attention to gender equality and social inclusion.
5. **Monitoring and Evaluation (M&E) System** – Each proposed activity requires a monitoring and evaluation system that properly assesses the outputs of the program, based on the objectives of ARC and ARC reporting requirements. The M&E system should be based, where possible, on the existing M&E system of the proposed intervention. Full information on the M&E system must be provided.

Countries are also required to submit documentation to support the information provided, including regarding the feasibility and adequacy of the systems proposed to carry out the functions described in the plan, and the national (including partner) implementation capacity to execute the plan efficiently.

As much as possible, the systems proposed across all five areas should build on existing and tested activities and processes, and work with identified partners that the country has worked with in the past. All proposed procurement, needs assessment, targeting and M&E systems must be sufficiently robust to ensure transparency and accountability in the use of funds associated with ARC.

Review process

When an Operations Plan is finalized through in-country processes, the country submits it to the Secretariat, which in turn submits it to the Technical Review Committee (**TRC**) comprised of seven independent experts. The TRC reviews and evaluates the Operations Plan, and provides a report of its assessment (the **TRC Report**) to the Peer Review Mechanism (**PRM**) of the Board.

The PRM, which includes three members of the Board, conducts its own independent evaluation of the Operations Plan, taking into consideration the TRC Report. The PRM then issues a report to the full Board (the PRM Report) with its recommendations regarding whether the Operations Plan has met the criteria set by the Board.

The Board takes the final decision regarding whether an Operations Plan has met the CP Standards.

Glossary

ARC (African Risk Capacity) was established in 2012 as a Specialized Agency of the African Union (AU), with 18 Member States that signed the Establishment Agreement initially, which has grown to 33 Member States by the end of 2018. ARC aims to provide insurance products that help protect from the impacts of extreme weather events, such as drought.

CCR (Caisse Centrale de Reassurance) is a public-sector reinsurer established in 1946 which provides insurers operating in France with multi-peril coverage against natural catastrophes and other risks.

CCRIF SPC (Caribbean Catastrophe Risk Insurance Facility) is an entity established in 2007 that provides insurance cover for hurricane, earthquake and excess rainfall to its, as in 2018, 18 Caribbean government-members and one Central American government member.

CCS (Consorcio de Compensación de Seguros - Insurance Compensation Consortium) is a state-owned entity established in 1941 that provides insurance cover for natural and terrorism disasters in Spain.

Disaster liquidity is the short-term liquidity necessary in the aftermath of disasters to support response and start recovery efforts while maintaining essential government service.

Exposure refers to the inventory of elements such as citizens, infrastructure, housing, production capacities and other tangible human and natural assets in an area in which hazard events may occur. Measures of exposure can include the number of citizens or types of assets in an area.

FEMA (Federal Emergency Management Agency) is an agency of the United States Department of Homeland Security with the purpose to coordinate the response to a disaster that has occurred in the United States and that overwhelms the resources of local and state authorities.

Financial protection is the financial resilience of governments, private sector and citizens through insurance-based mechanisms.

FONDEN (Fondo de Desastres Naturales - Natural Disasters Fund) is a public entity established in 1996 that provides insurance cover to the Mexican States and the Federal Agencies against natural disasters.

Hazard is the condition that can cause a disaster such as a hurricane or a tsunami.

Indemnity insurance is a contractual agreement in which the insurer guarantees compensation for actual losses or damages sustained by the insured.

Modelled loss is the loss estimate determined by a modelled representation of a catastrophe event that represents the underlying insurance risk. The event parameters are fed into a catastrophe model to calculate the modelled loss.

NFIP (National Flood Insurance Program) is a program created by the Congress of the United States in 1968 through the National Flood Insurance Act of 1968 that aims to reduce the impact of flooding on private and public structures by providing affordable insurance to property owners, renters and businesses and by encouraging communities to adopt and enforce floodplain management regulations.

Parametric insurance is a type of insurance that uses a parameter or an index of parameters of the catastrophic event as triggers for issuing a payout. Such insurance products may combine a mix of triggers from indemnity to industry loss, to the occurrence of specific parameters of a peril, such as wind speeds within a specified zone. Such products can also be linked to *modelled* losses (as opposed to actual claims for losses), triggering a payment when losses exceed a particular threshold. However, they do not have to be linked specifically to modelled claims for property loss.

Peril is the direct cause of loss such as flood or earthquake.

Risk is the possibility of loss. (More elaborate definition needed)

Risk Financing is the financial protection of populations against disaster events to increase the ability of national and local governments, homeowners, businesses, agricultural producers, and low-income populations to respond to disasters.

Protection gap is the gap between the insured and actual economic losses caused by large-scale catastrophic events. It refers to a global problem, affecting all countries, and referring to the whole uninsured and underinsured population including citizens, companies and governments.

Protection Gap Entity (PGE) is the entity that brings together different market and non-market stakeholders in an effort to address the protection gap by transforming uninsured risk into insurance-based products that can be transferred onto government balance sheets or into global financial markets in order to provide capital for recovery following a disaster.

Preparedness is the development of early warning systems, support of emergency measures and contingency planning to prepare *ex-ante* for disasters.

Risk mitigation refers to taking action to reduce the adverse effects of disasters.

Risk identification is about identifying, assessing and analyzing risk, typically as a technical capability supporting the quantification and communications of risk assessments and risk communication.

Resilient reconstruction is the ex-post reconstruction of property and the built environment for quicker, more resilient disaster recovery. (actually, these two elements are usually in competition - it is hard to build back better more quickly than building back the way it was before - so it is almost always a trade-off which should be recognized in this definition)

Risk reduction is the reduction of risks in society by implementing structural and non-structural measures in policy and investment.

Vulnerability refers to the propensity of exposed elements such as individuals, a community, and assets to suffer adverse effects of hazard events.

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